Exhibit E

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF NEW JERSEY

IN RE: JOHNSON & JOHNSON TALCUM POWDER PRODUCTS MARKETING, SALES PRACTICES AND PRODUCTS LIABILITY LITIGATION ***THIS DOCUMENT RELATES TO ALL CASES***	**MDL NO. 16-2738 (FLW) (LHG)**

EXPERT REPORT OF LAURA WEBB, PHD FOR GENERAL CAUSATION *DAUBERT* HEARING

Date: February 25, 2019

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Laura Webb, Ph.D.

Evaluation of the Formation of Talc Ores in the Fontane, Southern Vermont and Guangxi Talc Mines

1.0 Executive Summary

I have been asked to prepare a report focused on the scientific principles that govern the formation of mineable high-grade talc deposits used in the manufacture of Johnson's Baby Powder and Shower to Shower, and to investigate the possible relationship of such deposits, or lack thereof, to amphibole asbestos. This charge includes evaluating plaintiffs' experts' reports by Dr. Cook and Dr. Krekeler, and addressing differences in the formation of amphibole minerals with different crystal habits (e.g., asbestiform vs. prismatic) and the physical and chemical properties that impact biopersistence and toxicity.

Based on my review of materials, my educational background and professional experience as a geologist, my expert opinions are provided below with a reasonable degree of scientific certainty. My main conclusions are as follows:

A. Plaintiffs' experts' reports fail to appropriately synthesize key data and observations available in the peer-reviewed scientific literature that are pertinent to understanding the issues in this litigation. The body of evidence in the published scientific literature does not support the assertion that there is/was asbestos in cosmetic-grade talc deposits mined for use in Johnson's Baby Powder and Shower to Shower; nor do geologic principles suggest that there should be, based on a review of the local and regional geologic data.

B. Talc is a common metamorphic mineral in metamorphosed ultramafic and carbonate rocks. However, mineable high-purity talc deposits are the result of special cases of intense metasomatism (an uncommon form of metamorphism discussed below in Section 4.0) in which the chemical composition of an original rock is changed to something closer to that of the talc mineral composition. The conditions associated with this transformation to create the talc ores mined for Johnson's Baby Powder and Shower to Shower were not amenable to asbestos formation.

C. There is no well-founded, scientifically-sound evidence in the peer-reviewed scientific literature for an association of amphibole asbestos with the talc deposits of concern. Based on reviews of the geology associated with the applicable mines, and the pressure and temperature histories recorded by the rocks, any amphibole found in Johnson's Baby Powder and Shower to Shower derived from the Fontane, southern Vermont and Guangxi talc mines would likely be incidental actinolite or tremolite cleavage fragments from non-asbestiform amphiboles most likely derived from the margins (blackwall zones) of the talc deposits.

D. Amphibole cleavage fragments are, in general, much less chemically-resistant and have different surface chemistries than their asbestiform counterparts, for which other distinctive properties include flexible bundles of fibrils (typically less than 0.5 microns in diameter) with high tensile strength.

2.0 Summary of Qualifications

I am a geologist who specializes in using the tools of petrology (the origin and evolution of rocks discerned from mineralogical evidence), structural geology (interpreting rock deformation) and geochronology (radiometric dating) to understand the histories of rocks and regions. I obtained my Bachelor of Science in Geology from the University of California at Los Angeles in 1993 and my Ph.D. in Geological and Environmental sciences from Stanford University in 1999 (see CV attached as Exhibit A). After a postdoctoral appointment at the University of Geneva in Switzerland from 1999–2000, I moved to Syracuse University in New York, where I was a geochronology laboratory manager from 2000–2008 and held a Research Assistant Professor appointment from 2004–2012. In the fall of 2008, I began my career

at the University of Vermont (UVM) as a tenure-track faculty member in the Department of Geology. In 2014, I was promoted with tenure to Associate Professor. I am a member of the following professional societies: Geological Society of America, Mineralogical Society of America, American Geophysical Union, Vermont Geological Society and the American Association for the Advancement of Science.

Beginning with my early academic training as a geologist, I have worked extensively in regions with complex geologic histories, such as those in Italy, Vermont and China. Based on prior research projects and/or themes, I have familiarity with the regional geology of the Fontane and Guangxi mine regions and have experience working near the southern Vermont mines. I have (co)authored 33 peer-reviewed scientific papers (32 published and one currently in press) with an additional two manuscripts currently in revision or review. A common theme is the integration of microscopic-scale observations of the relationships between mineral growth and deformation with outcrop data and regional geological and geophysical data (e.g., Webb et al., 1999, 2010, 2014). These data facilitate understanding of the pressure-temperature-time-deformation history of rocks and the resulting implications for the tectonic evolution of regions. My teaching at UVM spans the scope of disciplines I employ in my research and includes those that are essential to a holistic understanding of the formation of talc deposits and assessing any possible relationship to asbestos. Such courses include Petrology, Microstructures, Geochronology and Tectonics.

I am being compensated at the rate of $450 per hour for my expert work.

3.0 Minerals: Definitions and Important Concepts

Rocks are composed of one or more minerals. Minerals are naturally occurring inorganic compounds defined by their chemical compositions and unique crystalline structures. Minerals are classified based on these properties. In the case of talc deposits, geologists are mostly concerned with carbonate and silicate minerals that incorporate CO_2 and SiO_2 in their crystal structures. The mineral talc is a phyllosilicate (Figure 1), or sheet silicate, with the idealized chemical formula of $Mg_3Si_4O_{10}(OH)_2$.

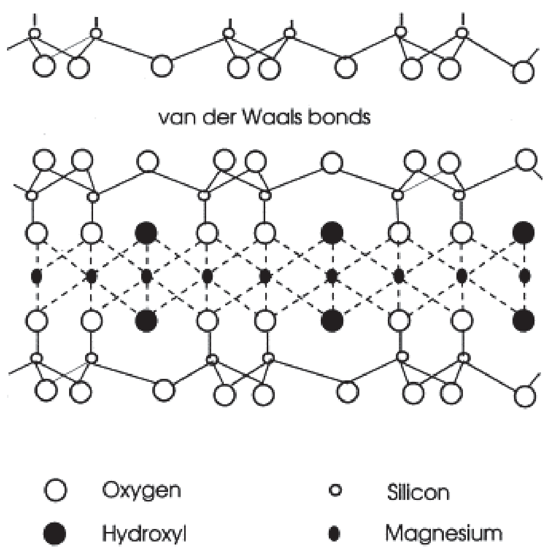

Figure 1. *Ball and stick model of the crystal structure of the mineral talc (from Huang and Fuerstenau, 2001). Talc sheets consist of Si tetrahedral, Mg octahedral, and Si tetrahedral layers (T-O-T). Weak van der Waals bonds hold the T-O-T sheets together, giving talc its platy habit.*

Many minerals can exhibit solid solution (i.e., be uniform solid mixtures), where cations (positively charged ions) with similar size and charge may substitute for one another in a mineral structure, allowing for known ranges in chemical composition for a given mineral. For example, forsterite is the pure magnesium-rich end-member of the mineral olivine (Mg_2SiO_4), and fayalite is the iron-rich end-member (Fe_2SiO_4). Almost all olivine found in nature contains some Fe and Mg and is thus a solid-solution of these two compositional end-members. Likewise, A small amount of Fe may substitute for Mg in talc crystals depending on various variables, including the chemistry of the geologic system and the pressure and temperature under which mineral formation and/or recrystallization occurs.

Structure and chemistry control all physical characteristics of a mineral, such as density, strength, mineral habit, cleavage, color and chemical stability. Habit is a term that refers to the general shape of the mineral, which is a function of the crystallographic structure as well as the conditions of formation. Table 1 defines common habit terms. Cleavage refers to weak planes in a crystal structure that influence how minerals break and controls the shape of crystal fragments. Cleavage planes may be described qualitatively as perfect, good, poor or indiscernible (synonyms may also be used). For example, talc crystals typically exhibit a platy or plate-like habit and have perfect cleavage along one crystallographic plane. This cleavage corresponds to the planes of weak van der Waals bonds (Figure 1). In other words, when forces are applied to talc crystals, the strongly-bonded T-O-T sheets remain intact and slip will occur along the weak forces of attraction between the sheets. This property is what gives talcum powders a slippery feel.

Table 1. *Examples of common terms used to describe mineral habits.*

Term	Definition
Acicular	Needle-like appearance, visible to naked eye.
Asbestiform	Having the habit of asbestos, including: "fiber-like morphology and dimensions; enhanced strength and flexibility; diameter-dependent strength; increased physical and chemical durability; and improved surface structure (i.e., relatively free of defects)." (NRC, 1984).
Bladed	Long, flat and thin.
Blocky or equant	Roughly equidimensional (e.g., boxy).
Fibrous	The appearance of clusters of minerals with long aspect ratios, often parallel to one another or radiating, that may or may not be separable. Often used synonymously with terms such as acicular, asbestiform and filiform.
Massive	No clear structure or dominant shape apparent.
Filiform or capillary	Thread-like appearance.
Platy	Sheet-like appearance.
Prismatic	Elongate with faceted sides.
Tabular	Having a rectangular shape and relatively thin or with moderate thickness.

Serpentine refers to a subgroup of phyllosilicates that includes about 20 minerals, including antigorite, chrysotile and lizardite (Rakovan, 2011). Serpentine minerals are 1:1 layer silicates. While the chemical formulas may be similar, Figure 2 illustrates how each has a unique crystal structure, making each a distinct mineral. Lizardite tends to most commonly occur as small (micron-scale) platy or elongate mineral

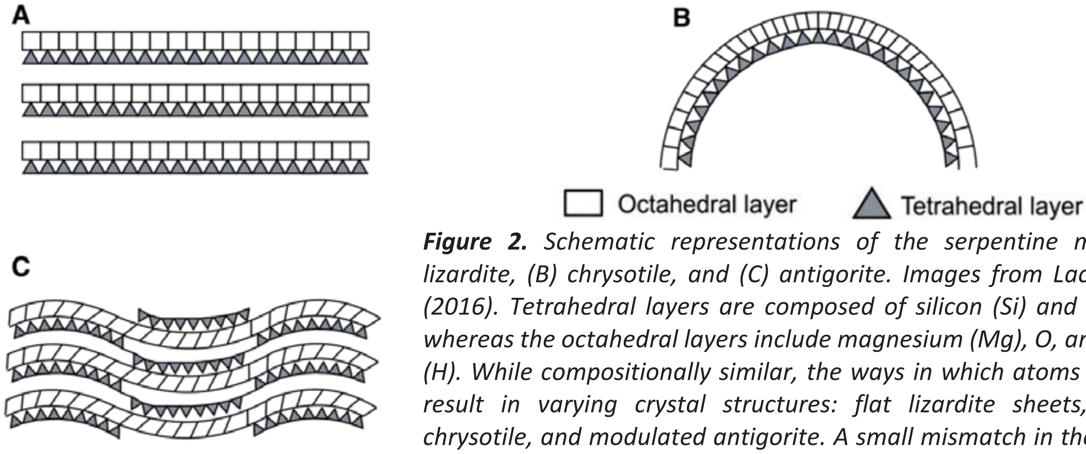

Figure 2. *Schematic representations of the serpentine minerals (A) lizardite, (B) chrysotile, and (C) antigorite. Images from Lacinska et al. (2016). Tetrahedral layers are composed of silicon (Si) and oxygen (O), whereas the octahedral layers include magnesium (Mg), O, and hydrogen (H). While compositionally similar, the ways in which atoms are bonded result in varying crystal structures: flat lizardite sheets, cylindrical chrysotile, and modulated antigorite. A small mismatch in the size of the octahedral and tetrahedral sheets in chrysotile results in the mineral's characteristic cylindrical shape.*

grains, antigorite tends to form coarser grained (millimeter-scale) flaky crystals, while chrysotile (serpentine asbestos) forms long hollow scrolls or cylinders with maximum outer diameters on the order of 150 angstroms (~0.015 microns) (Evans, 2004).

Amphibole minerals (Figure 3 [p. 5]) are members of the inosilicates that can exhibit a range of compositions (i.e., solid solution) (Table 2 [p. 6]). Which amphibole(s) are present in a rock (e.g., actinolite or anthophyllite) depend on the chemistry of the rock and its geologic history. Likewise, whether an amphibole is prismatic or asbestiform is strongly dependent on pressure and temperature, volume and composition of fluids and the deformation history of the rock at the time of its formation. Details relevant to these topics are discussed in subsequent sections of this report.

In cases where the amphibole crystal shape is well developed (i.e., prismatic), amphiboles are typically hexagonal in cross-section (Figure 3b). In general, amphiboles have two good cleavages that coincide with the {110} crystallographic planes (labeled in Figure 3b). Figure 3c illustrates how, in cross-section, these cleavage planes intersect in a diamond shape (see also upper left image in Figure 4 [p. 8]) and that the long axis of cleavage fragments are typically parallel to the c-axis of the mineral.[1]

While asbestiform minerals may be called fibrous, fibrous is not exclusively synonymous with asbestiform. The term fibrous is frequently used many ways by scientists, often applied to mineral habits with long aspect ratios that range in form from bladed to acicular to asbestiform (Zoltai, 1978; Ross et al., 2008; Belluso et al., 2017). Several different regulatory definitions also exist and must be distinguished as such (see summary in Wylie and Candela, 2015). For example, elongate mineral particle (EMP) has been employed as a term encompassing all structures with aspect ratios greater than 3:1, and therefore does not discriminate between asbestos and cleavage fragments (Kelse and Thompson, 1989). To further confound the issue, while asbestiform-amphibole-bearing deposits or rock units may contain non-asbestiform amphiboles (e.g., Harper et al., 2015), it is not the case that non-asbestiform (i.e., common) amphibole-bearing rocks inherently contain asbestiform amphiboles.

In this report, I use the term amphibole asbestos to refer to the regulated forms of amphiboles[2] that grow in an asbestiform habit. Non-asbestiform amphiboles refer to all other habits, such as prismatic, acicular, bladed (note that the latter two terms may be used synonymously with fibrous by certain authors). The issue of how amphibole asbestos differs from non-asbestiform amphiboles is further addressed below.

[Figure 3 on next page]

[1] Three-dimensional objects are often described using x, y, z coordinates for three mutually-perpendicular axes. Minerals are described in terms of a, b and c axes because these axes have different angular relationships to one another in different crystal systems.

[2] Regulated amphiboles refer to asbestiform riebeckite (crocidolite), cummingtonite–grunerite (amosite), anthophyllite, tremolite and actinolite, for which federal standards exist for occupational exposure or product concentration limits.

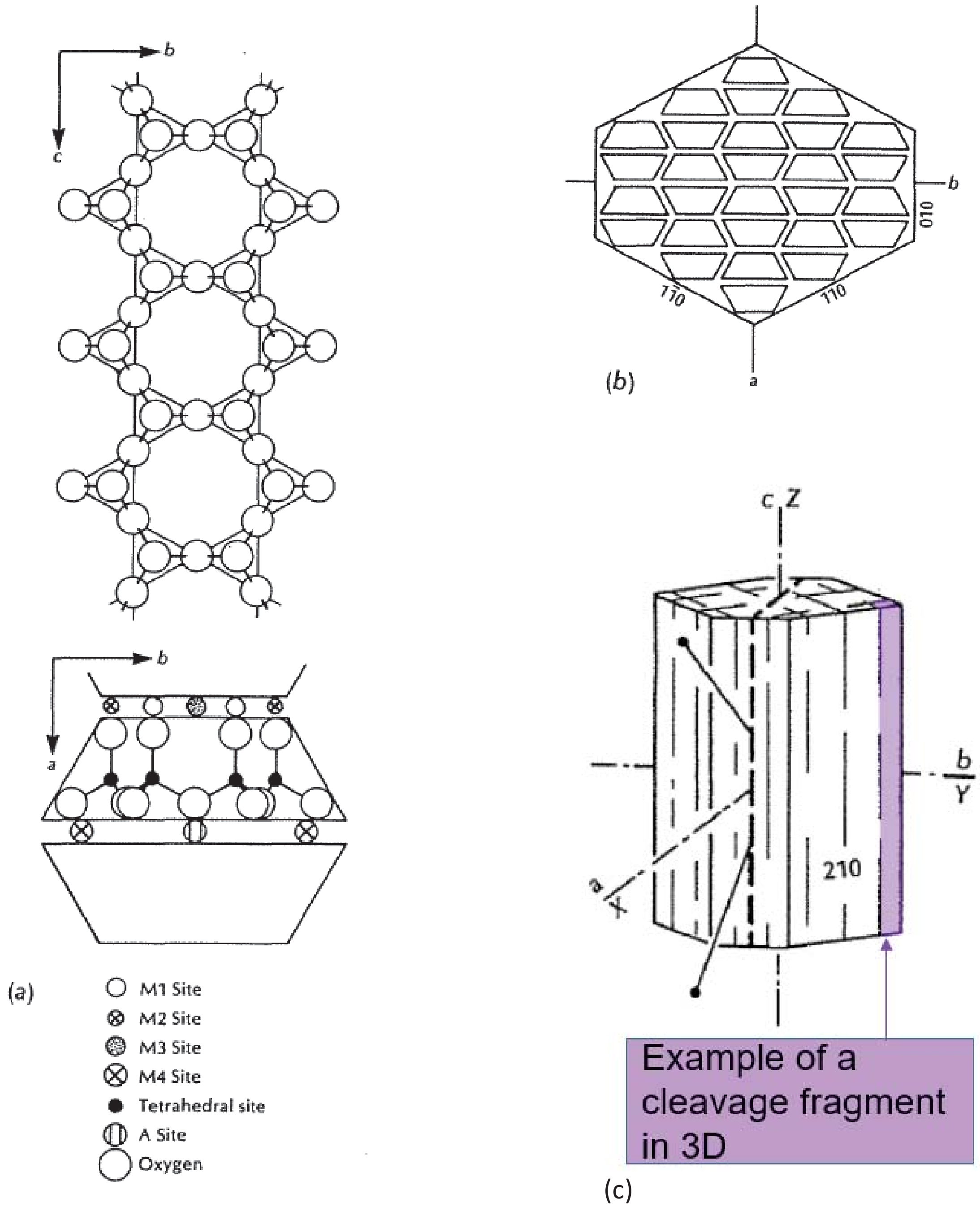

Figure 3. *Generalized amphibole crystal structure from Nesse (1991).* ***a)*** *Idealized double chain of tetrahedral (Si, O). The M1, M2, and M3 lattice sites correspond to elements associated with 'Y' as listed in Table 2, which are in octahedral coordination. Octahedral coordination means an atom is bonded with six neighboring elements or groups of elements (6-fold), defining the vertices of an octahedron. The M4 site corresponds to the elements associated with 'X' as listed in Table 2, which are in either octahedral or cubic (8-fold) coordination. The A site is a vacancy (empty site) in the amphibole structure.* ***b)*** *View down the c-axis of the crystal showing a typical amphibole cross-section (hexagonal). Amphiboles have two perfect cleavages that correspond to the {110} planes, forming diamond shapes in cross-section due to intersections forming ~120° and 60° angles.* ***c)*** *Three-dimensional view of an amphibole (anthophyllite) with the idealized crystal shape, showing a possible cleavage fragment with diamond-shaped cross-section (top) and long axis parallel to c-axis of the mineral. Another perspective is shown in Figure 4.*

Table 2. *Chemical formulas for minerals referred to in this report.*

Mineral	**Formula**
Talc	$Mg_3Si_4O_{10}(OH)_2$
Serpentine Group Chrysotile & lizardite; antigorite	$D_3[Si_2O_5](OH)_4$ D= Mg, Fe, Ni, Mn, Al, Zn $Mg_3Si_2O_5(OH)_4$; $Mg_{48}Si_{34}O_{85}(OH)_{62}$
Amphibole group Riebeckite (crocidolite) Cummingtonite-grunerite (amosite[a]) Anthophyllite Actinolite Tremolite	$AX_2Y_5((Si,Al,Ti)_8O_{22})(OH,F,Cl,O)_2$ A = ☐, Na, K, Ca, Pb^{2+} X = Li, Na, Mg, Fe^{2+}, Mn^{2+}, Ca Y = Li, Na, Mg, Fe^{2+}, Mn^{2+}, Zn, Co, Ni, Al, Fe^{3+}, Cr^{3+}, Mn^{3+}, V^{3+}, Ti, Zr ☐ = *Vacancy: Empty A site in the amphibole structure* ☐$Na_2(Mg, Fe^{2+})_3Fe^{3+}{}_2Si_8O_{22}(OH)_2$ ☐$Mg_7Si_8O_{22}(OH)_2$ to ☐$Fe^{2+}{}_7Si_8O_{22}(OH)_2$ ☐$(Mg, Fe^{2+})_7Si_8O_{22}(OH)_2$ ☐$Ca_2(Mg, Fe^{2+})_5\ Si_8O_{22}(OH)_2$ ☐$Ca_2(Mg, Fe^{2+})_5\ Si_8O_{22}(OH)_2$
Quartz	SiO_2
Sepiolite	$Mg_4(Si_6O_{15})(OH)_2 \cdot (H_2O)_6$
Forsterite (olivine; Mg-endmember)	Mg_2SiO_4
Enstatite (orthopyroxene; Mg-endmember)	$MgSiO_3$
Dolomite	$CaMg(CO_3)_2$
Calcite	$Ca(CO_3)$
Magnesite	$Mg(CO_3)$
Chlorite[b]	$Mg_5Al(AlSi_3O_{10})(OH)_8$

[a] *Amosite is the commercial term for amphibole asbestos principally composed of grunerite asbestos, but known to contain small amounts of anthophyllite and actinolite asbestos (see Zoltai (1981) and Wylie (2016) and references therein).*

[b] *Formula here is given for clinochlore, one of the most common members of the chlorite group; Fe^{2+} may substitute for Mg^{2+}, grading into the Fe-rich endmember, chamosite.*

3.1 Asbestos

Dorling and Zussman (1987) documented four major types of habit exhibited by amphibole minerals, which include "massive, prismatic, finely acicular, and asbestos." Prismatic and acicular habits are most common, and the asbestiform habit is very rare (Zoltai, 1979; Walker and Zoltai, 1979; Nesse, 1991; Klein, 1993; Veblen and Wylie, 1993). Amphiboles are estimated to compose ~2–5% of the Earth's crust (Nesbitt and Young, 1984), making them the fifth-most-abundant mineral. By area, 6–10% of the rock types exposed at the surface in the coterminous United States are amphibole-bearing (Wylie and Candela, 2015). Zoltai (1979) estimates that *less than 1% by volume of all amphiboles* may have crystallized with the asbestiform habit, and Wylie and Candela (2015) estimate that less than 0.1% of amphibole-bearing rock underlying the coterminous United States contain asbestos. The rarity of asbestos indicates that special conditions are required for its formation.[3]

[3] Asbestos is most typically found as veins in which fibers grew perpendicular to the host rock walls as "cross fibers" or (sub)parallel to them as "slip fibers" (Zoltai, 1981; Ross and Nolan, 2003; Evans, 2004). Veins, in general, are not

Indeed, amphibole asbestos and cleavage fragments are fundamentally different (Figure 4 [p. 8]). Structural differences internal to amphibole asbestos and non-asbestiform amphiboles include: 1) abundant twinning[4] in asbestos compared to non-asbestiform amphiboles, and 2) abundant subgrains and dislocations[5] in non-asbestiform amphiboles versus none in amphibole asbestos (Zoltai, 1981; Dorling and Zussman, 1987; Veblen and Wylie, 1993). Other key structural differences include the size, shape and surfaces of the grains themselves. When crushed, ground, etc. (communition), asbestos bundles break down into the individual fibrils (or smaller individual fibers), whereas non-asbestiform amphiboles tend to break along {110} cleavage planes. For this reason, the {110} plane is a common surface for (non-asbestiform) amphibole cleavage fragments (Figure 5 [p. 9]). In contrast, several authors have observed that amphibole asbestos fibrils commonly lie on surfaces that correspond to the {100} plane (Wylie, 1979, 2016; Dorling and Zussman, 1987; Brown and Gunter, 2003; Bandli and Gunter, 2014). In other words, amphibole cleavage fragments and amphibole asbestos, despite having the same mineral formula and same basic structure at the smallest scale, form in different ways and have different structural properties that control which crystallographic planes are typically exposed on their surfaces. In turn, because different crystallographic planes host specific elemental sites, which planes form mineral surfaces are significant factors in surface chemistry (Figure 5).

The differences described above influence particle size distributions observed for populations of mineral grains. Harper et al. (2008) demonstrated that width may be the most effective discriminator in size characterization studies of cleavage fragments versus asbestiform amphibole analogs. Fibril widths are typically less than 0.5 microns in diameter (Wylie and Candela, 2015; Wylie, 2016). Zoltai (1981) notes that if "fibers" are observed as single crystals (i.e., not associated with bundles) and have diameters larger than typical fibrils, they are capillary or filamentary crystals; strictly speaking, they are not asbestiform.

A key property of asbestos that made it commercially valuable is its high tensile strength and flexibility. This tensile strength is generally associated with low defect densities of fibril surfaces (Zoltai, 1981). Experiments have demonstrated that chemical resistance is a feature of the asbestiform habit, as explicitly noted in its definition, which is also attributed to the lower number of surface defects compared to non-asbestiform varieties (Walker and Zoltai, 1979; Gualtieri et al., 2018). Imperfections in the crystal structure due to deformation (i.e., dislocations or cleavage breaks) are known to be higher energy sites. Because the system wants to minimize its energy (see discussion of Gibbs free energy on p. 10), deformed regions of a crystal with structural imperfections are prone to faster dissolution rates (e.g., Schott et al., 1989; Lasaga and Lüttge, 2001). High densities of steps and kinks on mineral surfaces also show an effect of increasing dissolution rates (Arvidson et al., 2003). Steps and kinks are known to be common on growth

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uncommon in nature but asbestos-bearing veins are. The minerals that crystallize in veins and their habits are ultimately controlled by the metamorphic and deformation environment (rock chemistries, pressure, temperature, fluid volume and chemistry, rock strength, stress field). Observations of asbestos crystal surfaces and morphology are consistent with laboratory experiments that indicate asbestos forms by rapid growth in a supersaturated fluid-filled medium (Dorling and Zussman, 1987). The implication is that asbestos nucleates on rock surfaces and grows in fluid fluid-filled fractures or other voids (Evans, 2004; Ross et al., 2008). This association of asbestos with voids, brittle faults, and fractures indicate that, in addition to fluid composition, low temperature and/or pressures conditions are important factors in its formation.

[4] Twinning refers to symmetrical intergrowths within a larger crystal, where mirror images effectively occur across certain planes in the crystal lattice. In amphibole asbestos, twinning occurs along the {100} crystallographic plane shown in Figure 5.

[5] Subgrains are domains within a crystal lattice that are slightly misoriented relative to neighboring domains. They are bound by dislocations, which are analogous to small faults or offsets in the crystal structure.

surfaces of prismatic or acicular amphiboles and their cleavage planes but are not commonly associated with their asbestiform counterparts (Dorling and Zussman, 1987). Furthermore, because cleavage fragments form due to rock deformation, either by tectonic processes or by crushing and grinding, they are likely to dissolve faster. As a result, amphibole asbestos is associated with more chemically resistant Fe-bearing surfaces that can catalyze reactions compared to non-asbestiform amphiboles.

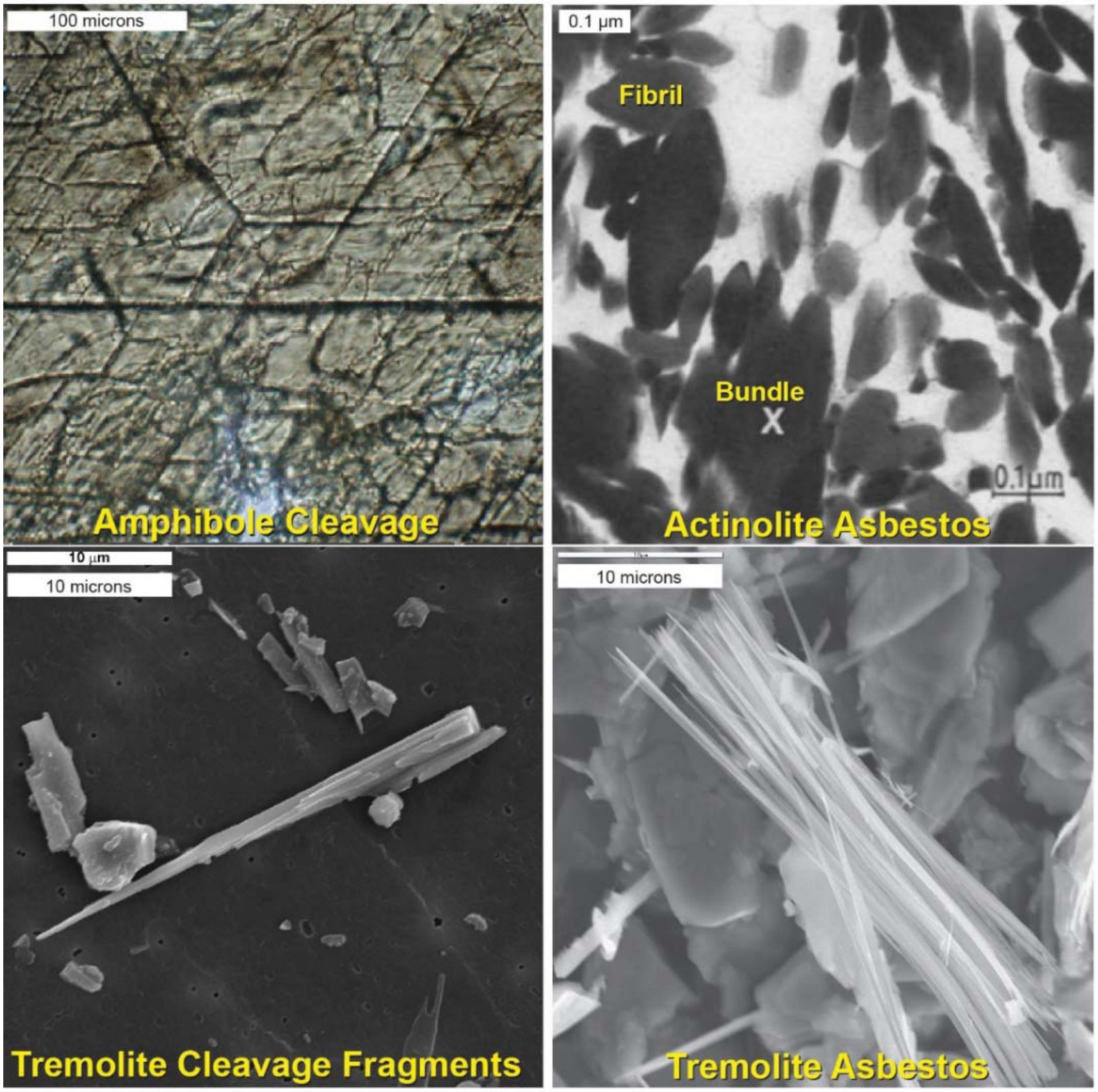
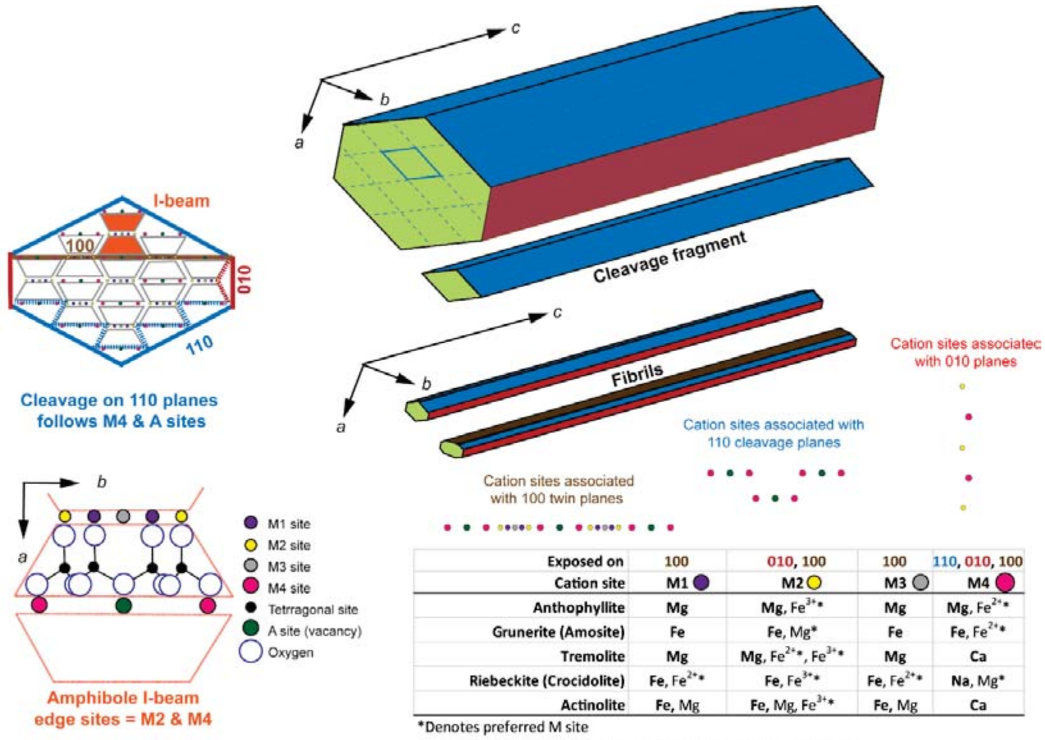


Figure 4. *Images comparing amphibole cleavage and cleavage fragments with amphibole asbestos. Upper images show basal cross-section views (i.e., a–b plane in Figure 5). Upper-left image shows well-developed {110} cleavage planes (appearing as dark lines bounding diamond-shaped crystal volumes) seen in polarized light microscopy. Image from: http://www.science.smith.edu/geosciences/petrology/petrography/hornblende/P1010004.jpg Upper-right electron micrograph from Dorling and Zussman (1987) shows fibrils and fiber bundles. Fibrils are typically less than 0.1 microns in width, whereas bundles (example denoted by authors with an "x") are larger clusters with more irregular outlines. Lower images show tremolite cleavage fragments and bundle(s) of tremolite asbestos fibrils taken with scanning electron microscopes (note similar scale of both images). Image on lower left is from https://usgsprobe.cr.usgs.gov/images/hexagonite.jpg; (hexagonite is a variety of tremolite). Image on lower right is from https://usgsprobe.cr.usgs.gov/images/asbestos_2.jpg.*



Exposed on	100	010, 100	100	110, 010, 100
Cation site	M1	M2	M3	M4
Anthophyllite	Mg	Mg, Fe^{3+}*	Mg	Mg, Fe^{2+}*
Grunerite (Amosite)	Fe	Fe, Mg*	Fe	Fe, Fe^{2+}*
Tremolite	Mg	Mg, Fe^{2+}*, Fe^{3+}*	Mg	Ca
Riebeckite (Crocidolite)	Fe, Fe^{2+}*	Fe, Fe^{3+}*	Fe, Fe^{2+}*	Na, Mg*
Actinolite	Fe, Mg	Fe, Mg, Fe^{3+}*	Fe, Mg	Ca

*Denotes preferred M site

Details re: Fe^{2+} and Fe^{3+} summarized from Pollastri et al. (2015, 2017)

Cations from Klein and Hurlburt (1993)

Figure 5. *Diagrams depict differences between cleavage fragments and asbestos fibrils in terms of crystallographic planes that form surfaces. I-beams represent the fundamental double-chain strands in amphiboles. Cation sites associated with each surface are shown, which depends on the type of amphibole. Details regarding Fe^{2+} and Fe^{3+} in table summarized from Pollastri et al. (2015, 2017), and cations from Klein and Hurlburt (1993).*

4.0 Formation of Talc Deposits: General principles of metamorphism and metasomatism

While talc is a common mineral in a variety of rocks, mineable cosmetic-grade[6] talc deposits are rare and require special conditions for formation. General principles of petrology—the study of the composition, occurrence and origin of rocks—are critical to understanding the formation process described below. For the non-geologist, baking provides a good analogy. That is, what comes out of the oven specifically depends upon: 1) the *composition* of ingredients that are mixed and in what ratios; 2) the *temperature* of the oven; 3) the *time* spent in the oven; and 4) the atmospheric *pressure* (i.e., at sea level vs. high elevation). The science of petrology, therefore, can be thought of as the study of rock recipes. In nature, as in the kitchen, recipes can be scaled and the availability of some ingredients (or another resource, such as time) will be a limiting the factor in the volume of desired products that can be made.

Metamorphism is a process in which changes in mineralogy occur when a rock is exposed to temperatures, pressures and/or fluids different from the conditions under which it formed. The concept of metamorphism is critical to understanding the formation of talc deposits and, in the case of the deposits used in Johnson's Baby Powder and Shower to Shower, why asbestos is not associated.

[6] Standards for cosmetic-grade talc include ≥ 90% mineralogical purity. (See Fiume et al., 2015).

When geologic conditions change, the atoms in a rock are reorganized into more stable configurations—mineral compositions, structures and assemblages—with a lower energy state. Metamorphism, by definition, involves solid-state chemical reactions that are dependent on the physical movement (diffusion) of chemical elements through a solid medium; fluids may or may not play a role and, generally, melt is absent except at very high temperatures (> 650 °C; 1202 °F). The laws of thermodynamics govern this process. Because metamorphism involves the diffusion of elements through solid crystal structures, lattice site by lattice site, or along grain boundaries, metamorphism typically occurs over geologic timescales (millions of years). High temperatures, the presence of fluids and deformation can enhance diffusion and thus recrystallization rates.

The term protolith refers to the original "parent rock," the bulk composition[7] of which has a primary control over the types and relative abundances of minerals that will comprise an equilibrium assemblage. An equilibrium assemblage is a combination of minerals that has the lowest possible Gibbs free energy[8] given the pressure, temperature and bulk composition of the system. As noted earlier, Gibbs free energy is also associated with structural defects in crystal structures and grain boundary geometries within the rock. The more defects and the more convoluted the geometries, the higher the energy of the system and the higher the driving force for recrystallization. For a given bulk composition, the equilibrium assemblage is a function of the pressure and temperature conditions of metamorphism, often described as metamorphic facies (see Figure 6 and examples in figure caption).

There are three main different types of metamorphism, and they are not mutually exclusive. Regional metamorphism generally occurs during mountain building processes, referred to orogenesis, such as when continents collide. Contact metamorphism occurs more locally, possibly during regional metamorphism, due to juxtaposition of a hot magmatic intrusion with colder wall rocks. Hydrothermal fluids, possibly associated with magmatic intrusions, can also be a driver of metamorphism due to local interactions between hot ion-rich fluids and the wall rocks with which they interact.

The results of metamorphism depend on open vs. closed system behavior. In a closed system, there is no change in the overall composition of the rock, only the rearrangement of atoms into new minerals occurs. The baking analogy is you can only use the ingredients you have on hand in the kitchen. In contrast, in an open system, chemical components may be added or lost by a rock during metamorphism (i.e., you can borrow a cup of sugar or eggs from your neighbor). The metamorphic process can make as much of whatever the conditions allow, until the conditions change, or one of the necessary elements runs out.

The formation of talc deposits is the result of metasomatism, a special case of open-system metamorphism in which the bulk composition of a rock changes due to interactions with fluids and/or the transfer of elements between neighboring rocks. For example: **Rock A + Fluid = Rock B** *-or-* **Rock A + Rock B = Rock C + Rock D + ...** The degree to which chemicals are exchanged across a rock-fluid or rock-rock boundary and the width of the alteration zone are strongly dependent on temperature, time, the presence of fluids and the intensity of chemical gradients. The process can be further enhanced by deformation.

[7] We can define the overall chemistry, or bulk composition, of a rock by major elements (> 2 wt. %), minor elements (2–0.1 wt. %) and trace elements (< 0.1 wt. %).

[8] At a specified pressure and temperature, Gibbs free energy (G) can be defined as $G = H - TS$, where H is enthalpy, S is entropy and T is temperature in degrees Kelvin.

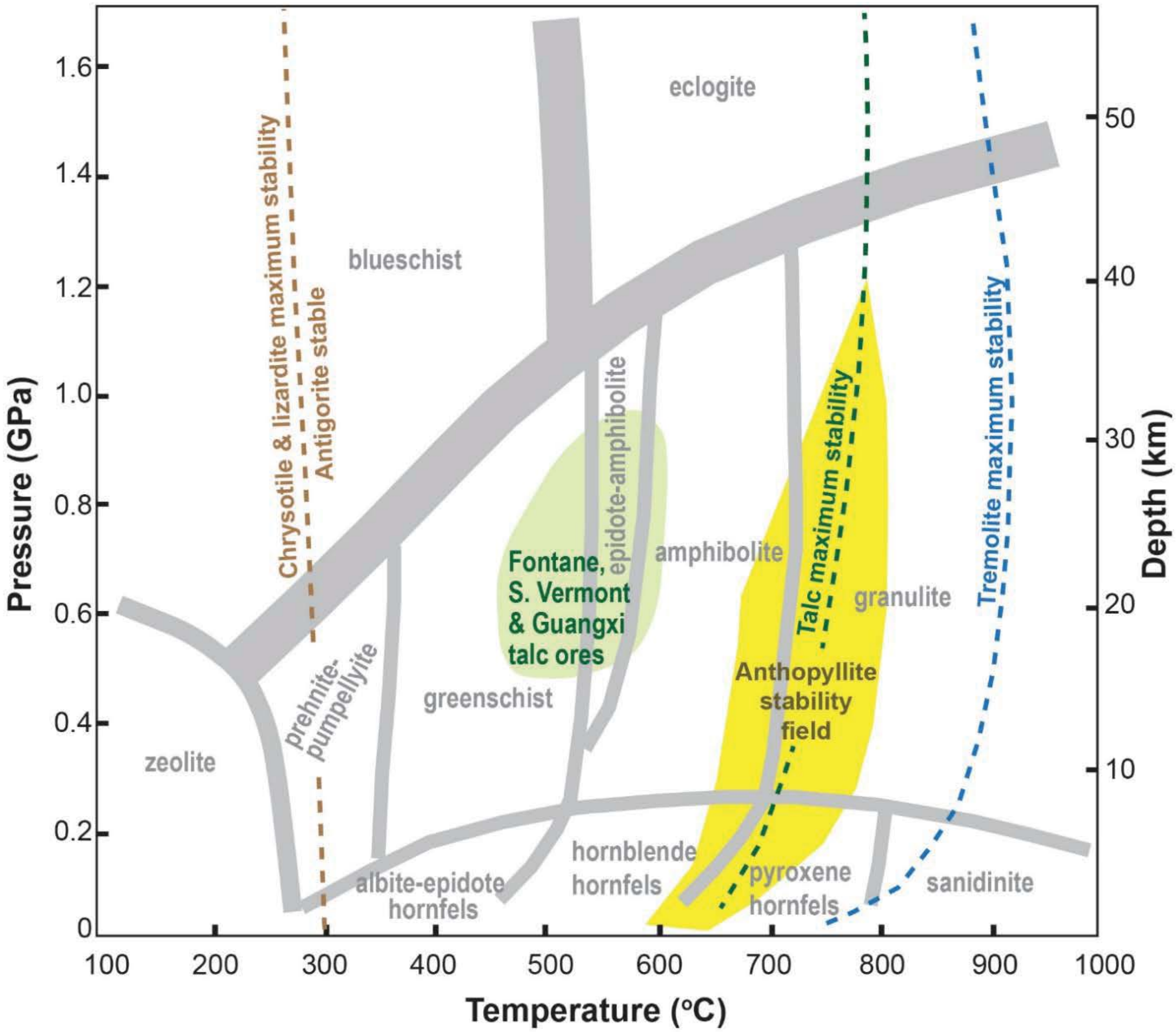


Figure 6. *Pressure-temperature diagram modified from Winter (2001) showing in gray the general boundaries of different metamorphic facies (e.g., greenschist facies) that represent conditions under which certain combinations of minerals (i.e., equilibrium assemblages) are stable as a function of a rock's bulk composition. The diagram is appropriate for water-saturated ultramafic rocks ($CaO-MgO-SiO_2-H_2O$). For example, burial of rocks during regional metamorphism is typically associated with greenschist–amphibolite-facies metamorphism. Greenschist-facies metamorphism of mafic rocks (e.g., basalt) will tend to result in a mineral assemblage including chlorite + albite + epidote + actinolite + quartz, whereas amphibolite-facies metamorphism of mafic rocks is typically associated with the assemblage hornblende + plagioclase + quartz. Mineral stability fields for the serpentine minerals taken from Evans (2004). Stability field of talc, tremolite and anthophyllite from Winter (2001); see also discussion in section 5.2. The green shaded field shows the general pressure and temperature conditions attending talc ore formation from which Johnson's Baby Powder and Shower to Shower were sourced, as described in the text. Guangxi talc ores formed at greenschist facies, southern Vermont and Fontane talc ores at up to lower amphibolite facies. Note that conditions favoring asbestos formation are generally associated with low-temperature and/or low-pressure conditions (zeolite, prehnite-pumpellyite and hornfels facies).*

4.1 A framework for analysis

By integrating observations made in the field and under the microscope with laboratory experiments, petrologists have constrained what minerals will form in a given rock type under different pressure and temperature conditions. Using this knowledge, we can either predict outcomes for different rock types (protoliths) and geologic histories or infer what the protolith and geologic history was based on observations of minerals and textures in rocks in the field and in petrographic thin sections.[9]

Figures 6 and 7 are examples of graphic representations petrologists employ to think about mineral assemblages and metamorphic reactions to constrain rock histories. For example, in Figure 6 above, the brown dashed line shows the stability fields of the different serpentine minerals as a function of pressure and temperature. Chrysotile and lizardite are stable (i.e., have the lowest Gibbs Free energy) at low temperatures, whereas antigorite is the most stable above ~300°C, depending on pressure. If we see chrysotile and lizardite veins in a serpentinite[10], we can infer that those veins formed at low-temperature conditions. Likewise, the green dashed line represents the maximum stability of talc, where it starts to undergo a metamorphic reaction to form anthophyllite + quartz + water. If in a thin section we see talc texturally associated with anthophyllite and quartz, we can infer that the rock records a frozen metamorphic reaction[11] that occurred at granulite-facies conditions, or temperatures ~700°C. This inference would be strengthened if we saw granulite-facies mineral assemblages in neighboring rock types.[12] The yellow field represents the stability field of anthophyllite in ultramafic bulk compositions. Its presence in a rock would testify to the rock having experienced upper-amphibolite or granulite facies conditions. If the maximum metamorphic grade recorded by a suite of rocks is lower amphibolite facies conditions (i.e., maximum temperature is less than ~650°C), ultramafic rocks in that suite of rocks would not contain anthophyllite; they would instead contain tremolite.

Figure 7 shows a chemographic projection, which is basically a graphical expression of the proportions of chemical components in rocks and the minerals that comprise them. To use a chemographic projection, we need to decide what our most important ingredients are. For carbonate and ultramafic rocks, the key chemical components are CaO, SiO_2, and MgO, and they are assigned to the three apices of the triangle. We need to consider fluids such as water (H_2O) and carbon dioxide (CO_2) and decide if they are abundantly available or are a limited resource. In the case of Figure 7 and the discussion that follows, the premise is that they are freely available to participate in reactions.

To plot a mineral or rock on the chemographic diagram, one must first determine the relative proportions of the chemical components. The mineral quartz (Qtz), SiO_2, plots at the SiO_2 apex. In this case, the mineral shares the same formula as the chemical component and 100% of the chemical composition of quartz is SiO_2. In the case of talc (Tlc), which has the formula $Mg_3Si_4O_{10}(OH)_2$, the chemical proportions are 3 MgO to 4 SiO_2 to 1 H_2O. Since water is ignored in the plotting scheme, we normalize the other chemical components to 100% and talc is plotted as 43% MgO and 57% SiO_2, therefore lying in that relative position

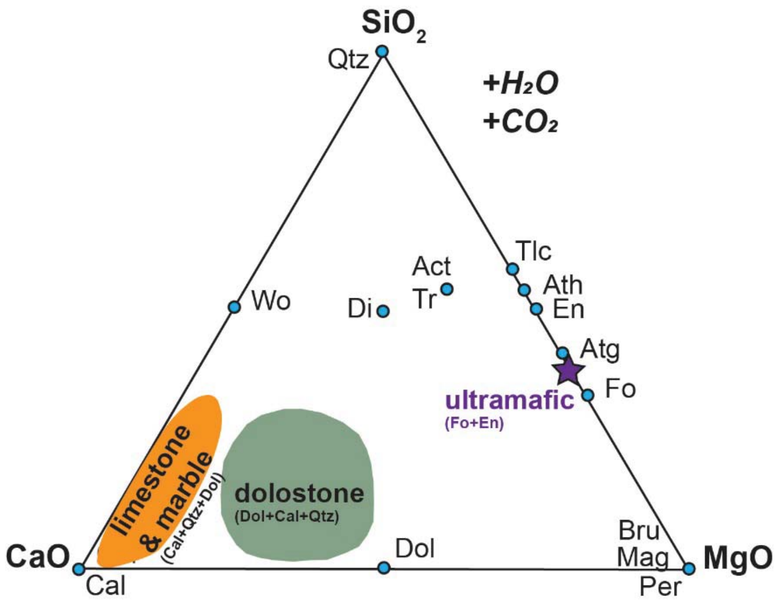
[9] A standard thin section is a polished 30-micron slice of a rock that can be examined using polarized light microscopy (petrographic microscope).

[10] Serpentinite is a rock predominantly composed of serpentine minerals.

[11] Metamorphic reactions can be preserved in rocks for a variety of reasons. For example, a chemical component might be limited ("runs out") or because of the timescales needed for reactions to go to completion, exceed the timescale of metamorphism.

[12] Petrology is effectively a forensic science, and for this reason petrologists work with suites of rocks rather than a single specimen.

on the line connecting the MgO and SiO_2 apices. The mineral tremolite (Tr), $Ca_2Mg_5Si_8O_{22}(OH)_2$, has the relative proportions (ignoring water) of 2 CaO to 5 MgO to 8 SiO_2, or 13.3% CaO, 33.3% MgO, and 53.3% SiO_2. Therefore, tremolite plotted based on these proportions lies closest to the SiO_2 apex, next closest to the MgO apex, and farthest from the CaO apex.



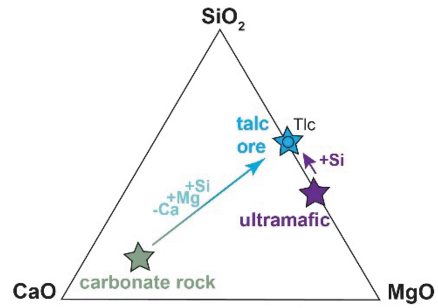


Figure 7. *Chemographic diagrams for the CaO-SiO_2-MgO chemical system for calcareous and ultramafic rocks modified from Winter (2001). Plot on left-hand side shows where rocks and minerals plot based on their chemical composition. Because of solid solution (e.g., the ability for Fe to replace Mg in a crystal structure), mineral positions may vary slightly due to actual mineral composition. Here, actinolite plots with tremolite because this simplified plotting scheme does not account for Fe. Abbreviations are as follows: Qtz = quartz, Act = actinolite, Tr = tremolite, Sep = sepiolite, Tlc = talc, Ath = anthophyllite, En = enstatite, Atg = antigorite, Fo = Forsterite, Bru = brucite, Mag = magnesite, Per = periclase, Dol = dolomite, Cal = calcite, Wo = Wollastonite and Di = diopside. Diagram in upper-right illustrates examples of changes in bulk composition due to metasomatism (open system metamorphism) resulting in the formation of high-purity talc deposits. See section 4.1 for discussion.*

One can plot rocks on a chemographic diagram based on their bulk composition as well as the combinations of minerals resulting from metamorphic processes. The mineralogy of the rock, including the relative proportions of minerals, must obey the rules of mass balance. That is, the relative proportions of the minerals must be consistent with the bulk composition. For example, the purple star shows a typical bulk composition of an ultramafic rock, an Mg-rich rock derived from Earth's mantle, that is composed of the minerals forsterite (Fo) and enstatite (En) (Table 2). During metamorphism, if the system is closed, no change in bulk composition occurs because no chemical components are added or lost from the system—that is except for water, which is freely available in this case. Metamorphism of ultramafic rocks in the presence of water at temperatures below ~500°C (~932°F) results in the formation of serpentine minerals[13], typically antigorite or lizardite depending on the temperature and pressure of metamorphism (Figure 6). Note that the mineral antigorite (Atg) plots very close to the purple star, as would lizardite. Based on the starting bulk composition, metamorphism in the presence of water would transform the ultramafic rock almost completely to antigorite at greenschist-facies conditions (~350–500°C; Figure 6), but there would have to be a little residual forsterite left in the rock because the bulk composition is richer in MgO than the mineral formula for antigorite (i.e., the excess MgO is manifest in preservation of some

[13] This transformation of ultramafic rocks into a serpentine-dominated mineralogy is called serpentinization.

of the original olivine). Because calcium is an essential chemical component in the tremolite, we would not predict any tremolite to form during metamorphism given the bulk composition of the ultramafic rock as defined in this example.

In the case of an open system, where chemicals other than H_20 or CO_2 may be added or lost due to chemical exchange between rock units or the introduction of silica-rich fluids via shear zones, faults or fractures, a talc deposit may form. For this to occur, a significant amount of SiO_2 must be added to the ultramafic rock system, ultimately shifting the bulk composition of the rock represented by the purple star to the position of talc (Tlc) on the graph (Figure 7). Likewise, in the case of a carbonate-rich (Cal ± Dol) protolith, SiO_2 and MgO must be added to the system to make a high-purity talc deposit.

The above principles highlight the fact that, while talc is a common metamorphic mineral in metamorphosed ultramafic and carbonate rocks, mineable high-purity talc deposits are the result of rare instances of rather extreme metasomatism, in which the bulk composition of a protolith is changed to something effectively matching (or very close to) the talc mineral composition.

5.0 Evaluation of talc mines used in Johnson's Baby Powder and Shower to Shower

Because each talc deposit is unique, an overview of the formation of talc deposits mined for use in Johnson's Baby Powder and Shower to Shower follows for the Fontane (Italy), southern Vermont and Guangxi (China) mines.

5.1 Sources of data

For the summaries and opinions provided below, I relied on peer-reviewed, published scientific literature and the examination of *primary sources* of data and observations. I emphasize the latter because, as discussed below (e.g., Section 5.3), there has been a lot of misinformation. Articles relating to the specific mines from which talcum powders were derived are somewhat sparse. In all cases, I integrated regional studies to understand the broader context and metamorphic conditions associated with the formation of the talc deposits. My examination of reports outside of the peer reviewed literature was very limited. For Guangxi talc ores, I used company documents (e.g., IMERYS413792) to find descriptions of geologic formation names and locations, and then used that information to search the peer-reviewed literature for relevant articles. This also facilitated assessing consistency between company reports and published findings.

In the case of both the southern Vermont talc mines and Fontane talc mines in Italy, I examined reports by Dr. Pooley[14] from the Department of Mineral Exploration at University College Cardiff in Wales. In my professional opinion, Dr. Pooley's reports are important records of data and observations that augment and are consistent with the published literature. Dr. Pooley sampled not only the talc ores, but representative samples of rock types included in and adjacent to the ore bodies. This sampling strategy is consistent with that required to understand the talc ores in the context of a geologic system and assess the potential for asbestos contamination. Based on my expertise, I focused on his petrographic thin section observations (polarized light microscopy) from which one can identify major, minor, and accessory minerals, their habits and their textural relationships (e.g., intergrowths, replacement textures, deformation at the microscale). I found his electron microscopy and X-ray diffraction data results to be consistent with the petrographic descriptions and photomicrographs.

[14] The report titles include: *Talc Product Safety and Purity Project: 1. Talc Ore Sampling – Fontane Mine – Italy; Report of Italian Mine Samples J & J.; Report of the Examination of Rock Samples from the Vermont Mine.*

The summaries provided below emphasize findings from the published literature, noting consistency between the published data and that in the industry reports examined.

5.2 Talc from the Fontane talc mines, Val Germanasca, Italy

The Fontane Talc Mine workings are in Val Germanasca in the Pinerolo district of the Torino province of Italy. Cadoppi et al. (2016), Sandrone et al. (1990) and Sandrone and Zucchetti (1988) indicate that the Fontane talc bodies are embedded within a pre-Carboniferous (i.e., older than ~355 million years) polymetamorphic complex of the Dora Maira Massif (southern blue map unit in Figure 8). The talc ores are associated with layers of schist, marble, and gneiss (Del Greco and Pelizza, 1984; Cadoppi et al., 2016), corresponding to metamorphosed mudstone, limestone and basalt, respectively. The talc ore bodies are of high purity and confined to a sheet-like body with local impurities that include lenses of carbonate or schist of varying size (Del Greco and Pelizza, 1984; Sandrone and Zucchetti, 1988). Cadoppi et al. (2016) report that the processes leading to Fontane Talc mineralization are still debated. The talc formation is hypothesized by some to have resulted from regional metamorphism of an Mg-rich clay horizon such as sepiolite (Table 2; Figure 7) (Sandrone and Zucchetti, 1988). However, juxtaposition of carbonate rocks, schists, and metabasalts (the prefix "meta" means metamorphosed) as layers that host the talc ores, and the inclusion of these rock types locally within the talc ores, are consistent with a metasomatic origin (i.e., metasomatism of a carbonate rock to a talc ore; Figure 7).

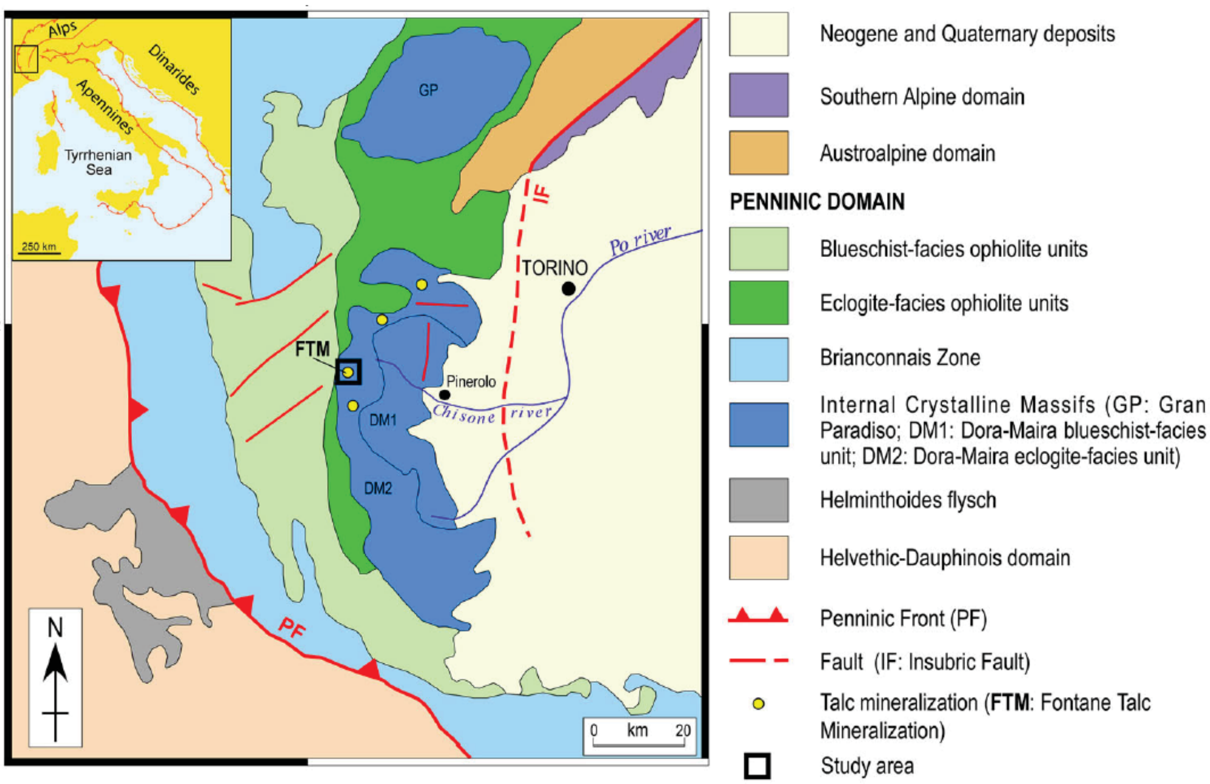


Figure 8. *Map showing location of the Fontane talc mineralization (yellow dots) from Cadoppi et al. (2016). The Fontane talc mines (FTM) are hosted within the old, poly-metamorphosed continental crust of the Dora Maira unit. Note that this suite of rocks (blue) are in a different geologic unit than the ophiolite (oceanic crust and mantle) units (light and dark green), where asbestos has been documented. The tectonic juxtaposition of these map units post-dates the formation of the talc (see discussion in text).*

The high-purity Fontane talc deposits formed early in the geologic history of the rocks and have been geologically stable since their formation. Integrated studies of metamorphism and deformation recorded by the talc ores and their host rocks indicate a complex polymetamorphic history in which the talc ores formed prior to the Cenozoic Alpine orogeny (i.e., the talc formed greater than ~60–35 million years ago) (Gasco et al., 2011; Cadoppi et al., 2016). Gasco et al. (2011) demonstrate that the rocks hosting the Fontane talc deposits, and thus the talc deposits themselves, never exceeded temperatures of ~575°C during the Alpine phases of metamorphism. This is important because studies have shown that talc, once formed, is stable up to at least 650°C (1202°F) and as high as 800°C (1472°F) depending on pressure (e.g., Pawley and Wood, 1995; see also Sandrone and Zucchetti, 1988, and references therein; Figure 6).

The formation and location of asbestos and talc in the western Alps are clearly separated in both space and time. Asbestos is well-documented in ophiolite (sections of oceanic crust and upper mantle, mainly mafic and ultramafic rocks) units in the Piemonte zone (Labagnara et al., 2013). However, the talc ore bodies have no relationship to the ophiolites nor any direct geologic contact with them. The juxtaposition of the ophiolites (green units) and the Dora Maira massif (blue unit) that hosts the talc ores is the result of the Alpine orogeny, which postdates the formation of the talc ores by hundreds of millions of years. While tremolite[15] is documented in the literature in some rock types adjacent to talc ores, and occasionally found in rock fragments included within the talc ore bodies (Sandrone and Zucchetti, 1988; Cadoppi et al. 2016), there are no reports of asbestos associated with rock units in the Fontane talc mines in the published, peer-reviewed literature (nor detections of it in tests of Fontane mine-derived talcum powders; e.g., Marconi and Verdel, 1990).

The minerals and textures reported by Dr. Pooley for samples of the Italian mines are consistent with the geologic data and metamorphic histories documented by the publications cited above. Dr. Pooley examined more than 40 rock samples from a variety of rock types adjacent to the talc ores, as well as the talc ores themselves and specimens discarded during the screening stage. No asbestos or asbestiform minerals are reported. The only amphibole(s) observed are non-asbestiform calcic amphiboles, principally tremolite. The tremolite documented is prismatic, coarse-grained and bladed, occurring in surrounding rock types (his samples I19, I32, I35), which are locally found as rock inclusions in ore bodies. Only one talc ore sample revealed tremolite found as long prismatic inclusions in garnet (sample I41). (See JNJTALC000165964; JNJTALC000347819).

In summary, the Fontane talc mines are hosted within a metamorphosed suite of crustal rocks including mudstone, carbonate and basalt protoliths. Based on the rock-type associations, the talc ores formed from metasomatism of carbonate rocks juxtaposed with Si-rich metasedimentary and Mg-rich metabasalts (in the presence of H_2O and CO_2) at temperatures up to ~575°C. In contrast to plaintiffs' experts' claims, there is no record of asbestos having formed in these rocks; the geologic conditions were unfavorable. Rather, the occurrence of asbestos in the region is associated with unrelated and spatially distinct ophiolite units.

5.3 Talc from southern Vermont, USA

The Vermont talc mines used for Johnson's Baby Powder and Shower to Shower are near Ludlow, Vermont (Figure 9). These talc deposits formed via metasomatism during the Acadian orogeny (Late Devonian, ~380–360 million years ago) at the interface between Mg-rich ultramafic (mantle derived) rocks juxtaposed with Si-rich metasedimentary rocks (Chidester et al., 1951; Cady et al., 1963; Sanford, 1982;

[15] Non-asbestiform tremolite.

Robinson et al., 2006). This metasomatic process is like that described in section 4.1 (i.e., metasomatism of ultramafic rock to talc). The age of the deposits was originally deduced from correlation of the foliations(s) exhibited by the talc deposit with those documented regionally, resulting from deformation during the Acadian orogeny.

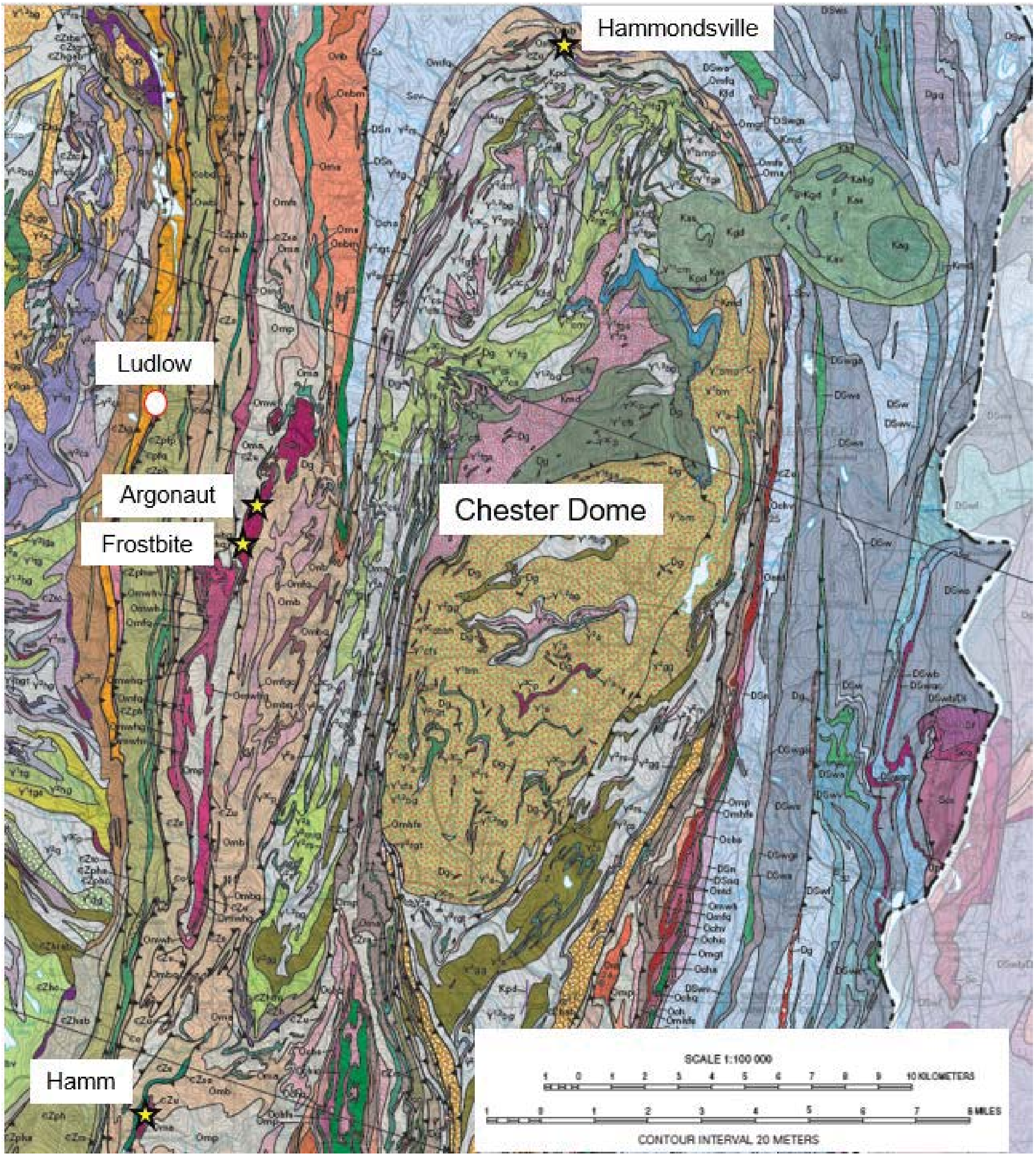


Figure 9. *Location of talc mines in the Ludlow region of southern Vermont. Talc for Johnson's Baby Powder and Shower to Shower came from the Hammondsville, Hamm and Argonaut mines. The Frostbite mine is also discussed in the text. The mines are associated with ultramafic rock units distributed within the Moretown Formation along the northern and western edges of the Chester Dome. Bedrock Geologic Map of Vermont from Ratcliffe et al. (2011). The complete version of this map, including the detailed index of rock units and map symbols, can be found here: https://dec.vermont.gov/geological-survey/publication-gis/VTrock.*

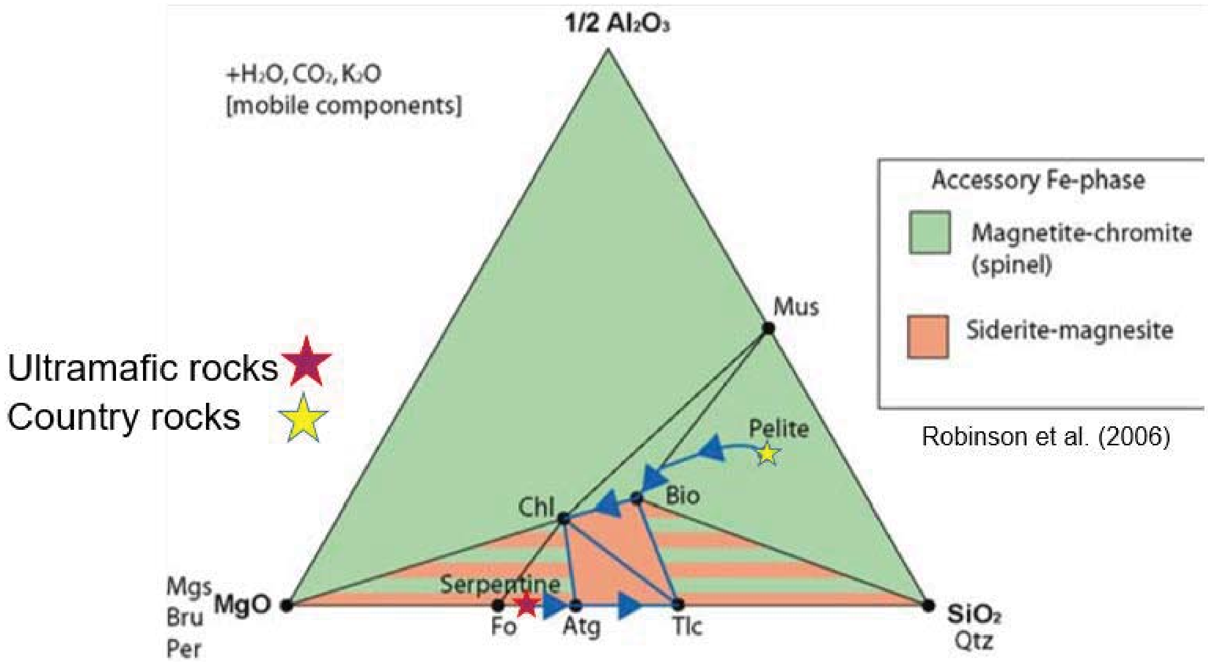
The most authoritative publication on the petrologic processes that control the formation of talc deposits associated with ultramafic bodies in southern Vermont is Sanford (1982). While Sanford (1982) did not study the Ludlow area deposits specifically, his case studies from Vermont and Massachusetts provide excellent context. Considered a classic, this work provides the basis for metamorphic petrology textbook discussions of the formation of talc deposits via metasomatism (e.g., Winter, 2001). Sanford's (1982) description of the Newfane quarry is an analog for the mines that produced cosmetic-grade talc based on the similarity in metamorphic conditions. Figures 10 and 11 show a chemographic diagram for the Frostbite mine in the Ludlow area as well as schematic representations of the mineralogical zonation resulting from metasomatism along the contact between an ultramafic body and metasedimentary country rocks. The diagram shown in Figure 11 is based on the Newfane quarry, located ~23 km (~14 mi) south of the Hamm mine and positioned similarly along the margin of the Chester dome. Depending on the bulk composition of the rock and the metamorphic grade, the amphiboles of note in rocks immediately adjacent to the talc ore are either actinolite or tremolite, with anthophyllite present only at the highest metamorphic grades (Sanford, 1982). More specifically, anthophyllite is predicted to form at T ≥ 650°C (1202°F; Figure 6), or upper amphibolite-facies conditions (Johannes, 1968). Such conditions are known to have been experienced in the core of the Chester Dome. Positioned along the flanks of the dome, the Hammondsville, Hamm and Argonaut Mines experienced *maximum* metamorphic conditions up to lower amphibolite-facies (T ≤ 600°C, or 1112°F) conditions based on the mapping of isograds[16] in Doll et al. (1961) and Karabinos et al. (2010); therefore, amphiboles in the suite of rocks present at these mines are most likely either tremolite or actinolite, depending on the bulk composition (actinolite in more Fe-rich bulk compositions).[17] The Hammondsville mine is documented by Gillson (1927) and Chidester et al. (1951). These authors noted coarse flaky talc, a lack of serpentinite, and only localized masses of actinolite, which would be derived from blackwall, or the margin of the silica-rich metasedimentary rocks juxtaposed with the ultramafic bodies (i.e., the edges of the mineable talc deposit).

As noted previously, Dr. Pooley sampled a variety of representative rock types in the southern Vermont mine. Data and observations presented in Dr. Pooley's report for the southern Vermont talc mine are consistent with Sanford's (1982) findings for the talc zone formation in rocks of the Newfane quarry, which experienced similar metamorphic pressures and temperatures as the Ludlow area mines. Pooley documented no asbestos and found actinolite present only locally (sample V9) at margins of the talc bodies. The actinolite shown in Pooley's photomicrograph is coarse-grained and prismatic, not asbestiform. The suite of minerals observed in the country rocks is consistent with those described above and shown in Figure 11. Dr. Pooley's data are also generally consistent with the findings of Robinson et al. (2006) for the Frostbite Mine—although the latter does not report any amphiboles.

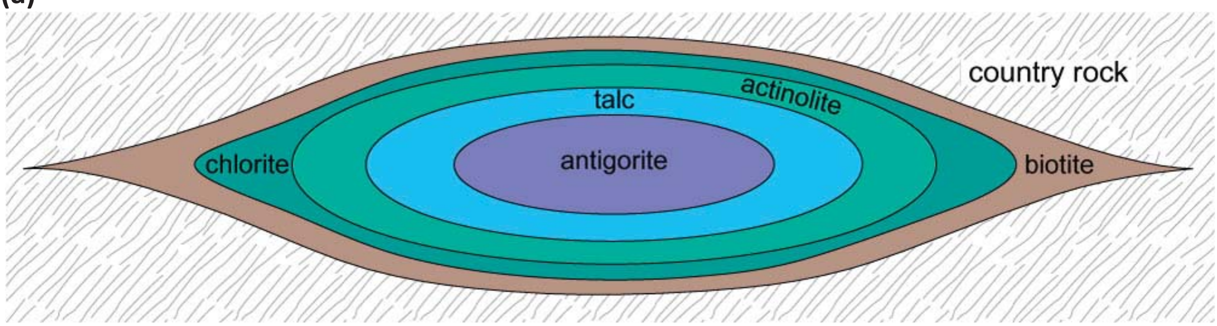
[Figure 10 on next page]

[16] Isograds are contours of equal metamorphic grade (i.e., demarcations of rocks that record similar pressures and temperatures of metamorphism based on their mineral assemblages).

[17] Note that other biopyriboles (Thompson, 1978; Bozhilov, 2013) have been documented as a function of bulk composition and metamorphic history. For example, at the Newfane locality, the thin epidote zone on the margins of the talc deposit shown in Figure 11 is known to contain intergrowths of hornblende, cummingtonite, and biotite interpreted to represent frozen metamorphic reactions (Sanford, 1982).



(a)



(b)

Figure 10. a.) *Chemographic diagram for the Frostbite Mine modified from Robinson et al. (2006). The diagram illustrates the chemical exchange between Mg-rich ultramafic rock and the Si-rich metasedimentary country rocks that resulted in the formation of talc deposits and accounts for a slightly different chemical system than that in Figure 7. Migration of SiO_2 from the country rocks (pelite, or mudstone, is the sedimentary protolith) into the partially serpentinized ultramafic body moved its bulk composition towards talc to form the talc deposit. Migration of MgO from the ultramafic body into the country rocks moved that bulk composition towards chlorite to form the chlorite-rich blackwall zone. These metasomatic reactions created mineralogical zoning schematically shown in b.* ***b.)*** *Schematic diagram from Winter (2001) showing the idealized mineral zonation resulting from metasomatic reactions between ultramafic pods or lenses and metapelites during regional metamorphism.*

[Figure 11 on next page]

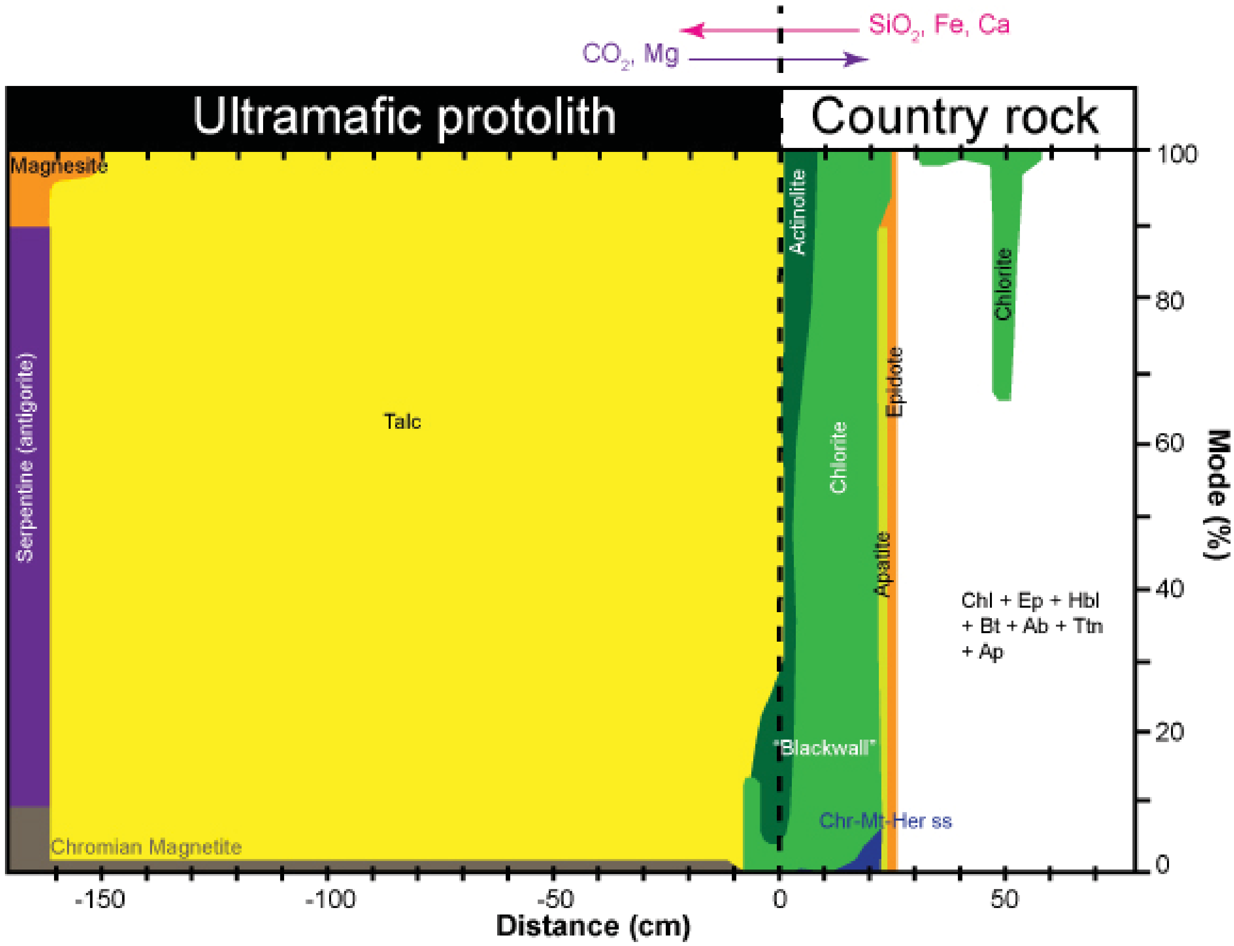


Figure 11. *Diagram depicting mineralogical zonation resulting from metasomatism of an ultramafic body in contact with metasedimentary rocks. The X axis is distance measured in outcrop and the Y axis is modal percent, or the relative proportion of each mineral depicted or listed in the graph. The original contact between the ultramafic rocks and the metasedimentary rocks corresponds to 0 cm along the X axis; negative distance is associated with distance into the ultramafic body and positive distance is into the country rocks. Chemical fluxes (i.e., diffusion of Si into ultramafic body from the country rock), due to strong compositional differences between the rock types, are shown by the arrows at the top of the figure. The redistribution of chemicals and the recrystallization of the rocks results in the formation of distinct mineralogical zones during regional metamorphism. The diagram depicts the blackwall zone, which is the chlorite-rich zone (± actinolite) on the country rock-side of the lithologic contact. "Chr-Mt-Her ss" is chromite-magnetite-hercynite solid solution; "Chl + Ep + Hbl + Bt + Ab + Ttn + Ap" is the general country rock mineral assemblage of chlorite + epidote + hornblende + biotite + albite + titanite+ apatite, which is indicative of epidote-amphibole-facies metamorphism.*

Regional studies are clear that asbestos formation in Vermont occurred during a different tectonic cycle and under different metamorphic conditions than talc ore formation (~60 to 100 million years prior). Hess (1933) studied the occurrence of chrysotile asbestos in ~150 ultramafic bodies in the Appalachians from Alabama to Newfoundland, including those in Vermont, noting that in the bodies associated with talc deposits 1) serpentinization always preceded steatization[18] and 2) that the chrysotile veins were

[18] Steatization is a term used in the literature for the formation of talc-carbonate rocks from metasomatism, with the talc-carbonate rock sometimes being referred to as steatite or soapstone.

associated with the older serpentinization event and were limited spatially to the ultramafic body (i.e., were never found in the country rocks). Similar conclusions were made by Chidester et al. (1951), a study specific to Vermont talc, as well as Chidester et al. (1978). The latter study was specifically focused on the asbestos-bearing rocks around Belvidere Mountain in the northern Vermont talc belt. More recent work by Honsberger and Laird (2018) modeled the metamorphic histories of the Stockbridge and Belvidere ultramafic bodies and concluded there were two distinct events: 1) an earlier phase of metamorphism during which serpentinization occurred in the presence of H_2O (with chrysotile asbestos forming locally in the latter stages of this event); and 2) a later event associated with steatization in the presence of H_2O and CO_2-bearing fluids. In other words, all publications are consistent that talc ore formation was unrelated to the formation of asbestos and occurred under different metamorphic conditions.

There are limited publications implying that asbestos is commonly associated with the ultramafic rocks in the southern Vermont talc belt (Van Gosen et al., 2006). I have reviewed these papers and detail my professional opinion and findings below.

Van Gosen (2006) summarized reported asbestos deposits in the northeastern United States. Of the 22 localities listed in Vermont, the reports are mainly of chrysotile, with amphibole asbestos being much more limited. In southern Vermont, there are five reported asbestos localities, none of which were mined for talc for Johnson's Baby Powder and Shower to Shower, that can be considered generally in the vicinity of the Ludlow area mines:

1) The Five Corners Mine is located ~11 km (~7 mi) WNW of the nearest cosmetic-grade talc deposit at the Hammondsville Mine. There, tremolite asbestos is stated to occur in ultramafic rocks hosted in the Ottauquechee Formation based on Perry (1929). However, the report of asbestiform tremolite in Perry (1929) is tenuous because the description of the minerals is not consistent with the definition of asbestiform in Table 1. I found a brief reference to chrysotile in the Five Corners Mine in Chang et al. (1965), but this was not included in the Van Gosen (2006) summary; nor have I found any citations that corroborate this finding. I also note the country rocks that host the ultramafic rocks at the Five Corners Mine are a distinctly different geologic formation than those hosting the cosmetic-grade deposits used in Johnson's Baby Powder and Shower to Shower, which are hosted in the Moretown Formation (i.e., they are a different belt of rocks with a different tectonic history).

2) The Bridgewater Hill occurrence is cited as reported in Perry (1929). It is ~19 km (~12 mi) NW of the Hammondsville Mine. Perry (1929) only states that "asbestos" was found as a loose piece of rock in a pasture, but the specific mineralogy and/or context of its geologic occurence is unknown. The country rock at this location is the Ottaquechee Formation, similar to that above for the Five Corners Mine.

3) Van Gosen (2006) notes a chrysotile occurrence in the Ludlow area, approximately ~2.4 km (~1.5 mi) NE of the Argonaut Mine, citing Chidester and Shride (1962) as cited in Van Gosen (2006). However, Chidester and Shride (1962) present no primary data or observations, and only cite Chidester et al. (1951) as their source. At issue here is the fact that Chidester et al. (1951) do not report any location information for their general report, making this reported locality impossible to evaluate.

4) Van Gosen (2006) indicates chrysotile is found in association with the Dover ultramafic body, which is ~27 km (~17 mi) SSE of the Hamm Mine. However, this occurrence is attributed to Chidester et al. (1951) and Chidester and Shride (1962). As noted above, the latter cites the former as its source of information and, once again, there is no documentation of asbestos in the Dover ultramafic body in Chidester et al. (1951).

5) The Chester Talc Mine, or Carlton Quarry, is listed in Van Gosen (2006) as an anthophyllite asbestos and possibly actinolite asbestos locality. The quarry is located ~10 km (~6 mi) NNE of the Hamm Mine and ~11 km (~7 mi) SSE of the Argonaut Mine. Again, Chidester et al. (1951) is cited as a source by Van Gosen (2006) but does not report asbestos at any specific locality. Another cited source, Gillson (1927), describes talc quarried here as low grade and suitable for some industrial purposes only. Two types of talc are noted: coarse flakes and fibrous pseudomorphs of actinolite; no asbestos is reported. Phillips and Hess (1936) describes needles of actinolite (i.e., acicular actinolite), some pseudomorphed by talc, but no asbestos. The occurrence of anthophyllite is summarized in Veblen and Burnham (1978). These authors describe complex intergrowths in the blackwall zone on the margin of the talc deposit where anthophyllite is replaced by intergrowths of chesterite, jimthompsonite, clinojimthompsonite and talc. Thus, the amphibole asbestos reported in Van Gosen (2006) is more consistent with '"transitional" phases' of Kelse and Thompson (1989) rather than amphibole asbestos. The predominance of anthophyllite at this locality is consistent with the location's position relative to mapped isograds (Doll et al., 1961; Karabinos et al., 2010), placing it at a higher metamorphic grade (higher temperature) than the cosmetic-grade deposits historically used in Johnson's Baby Powder and Shower to Shower.

In short, the sources cited by Van Gosen (2006) as documenting asbestos occurrences in southern Vemont do not actually report asbestos at any specific locality, are based on ambiguous terminology and/or are inconsistent with other reports and publications. As noted in Bain (1942), while talc associated with ultramafic bodies in Vermont is common, only about a third of these occurences are associated with "some fibrous magnesian mineral." In other words, asbestos may occur locally, but is not ubiquitous to talc-bearing ultramafic rocks.

Plaintiffs also rely on the Blount (1991) paper, but that is problematic in several ways. The data upon which the conclusions are based are not presented, only interpretations. This would/should preclude publication in any reputable scientific journal because there is no way to evaluate or reanalyze the data, such as employing other plotting methods that have been determined to be more meaningful discriminators of asbetos versus cleavage fragments when looking at large populations of data (e.g., Wylie, 2016; Chatfield, 2018). Additionally, the methodology implied in Blount (1991) indicates Dr. Blount only counted particles with aspect ratios ≥ 3:1 (as opposed to what is implied in Figure 6 from Blount (1991) for 'Talc I'), whereas the frequency diagrams in Campbell (1977) include aspect ratios < 3:1. This effectively renders the comparison of the datasets incorrect, as it would impact binning intervals thus the frequency distributions. Furthermore, it is not clear how the "tremolite" particle in Blount (1991) Figure 5, presumably representing tremolite asbestos from Sample I, was determined to be tremolite. At a minimum, the refractive index used (1.584) would not distinguish tremolite from other amphiboles present (Crane, 1992) or other trace minerals with appropriate densities that could have been concentrated by Blount's heavy liquid separation method. And finally, even Dr. Blount has questioned whether Sample I actually even came from Vermont.[19]

Overall, there are no data or observations, nor any petrologic argument, to support any claim of asbestos in the talc ores used in Johnson's Baby Powder and Shower to Shower from southern Vermont. The plaintiffs' experts' reports fail to make the distinctions between some talc formed during serpentinization driven by hydration of the ultramafic rocks, in which chrysotile formed locally under low-temperature (< 300°C) conditions, and talc ores that formed much later via metasomatism (in the presence of H_2O *and* CO_2) at medium pressure and higher temperatures (~500–600°C). They also accept at face value

[19] Deposition of Alice M. Blount, Ph.D. in Gail Lucille Ingham and Robert Ingham, et al., v. Johnson & Johnson, et al., April 13, 2018, 52:9–53:21.

generalizations about the association of talc and amphibole asbestos made by Van Gosen et al. (2004) that are not representative of the talc ores mined for Johnson's Baby Powder and Shower to Shower, and fail to understand the details of the local and regional geology. The latter is apparent from 1) their assumption that all ultramafic rock bodies in Vermont have the same origin and similar history and 2) failure to recognize the complex distribution of rocks of differnet metamorphic grade resulting from multiple tectonic events.

5.4 Talc from the Guangxi Province in China

Little information is available in the peer-reviewed published literature on the talc deposits in the Guangxi Province in China. The geology of the Longsheng County talc mines of interest (Jizhua, Tongzishan, Guping and Shanglang mines) is deduced from Li (1979), Yao et al. (2016) and Zhao et al. (2018). The talc deposits are hosted in dolomitic marbles of the Hetong Formation in the Danzhou Group (Figure 12), which also includes metamorphosed sandstones and mudstones intercalated and intruded by mafic igneous rocks.

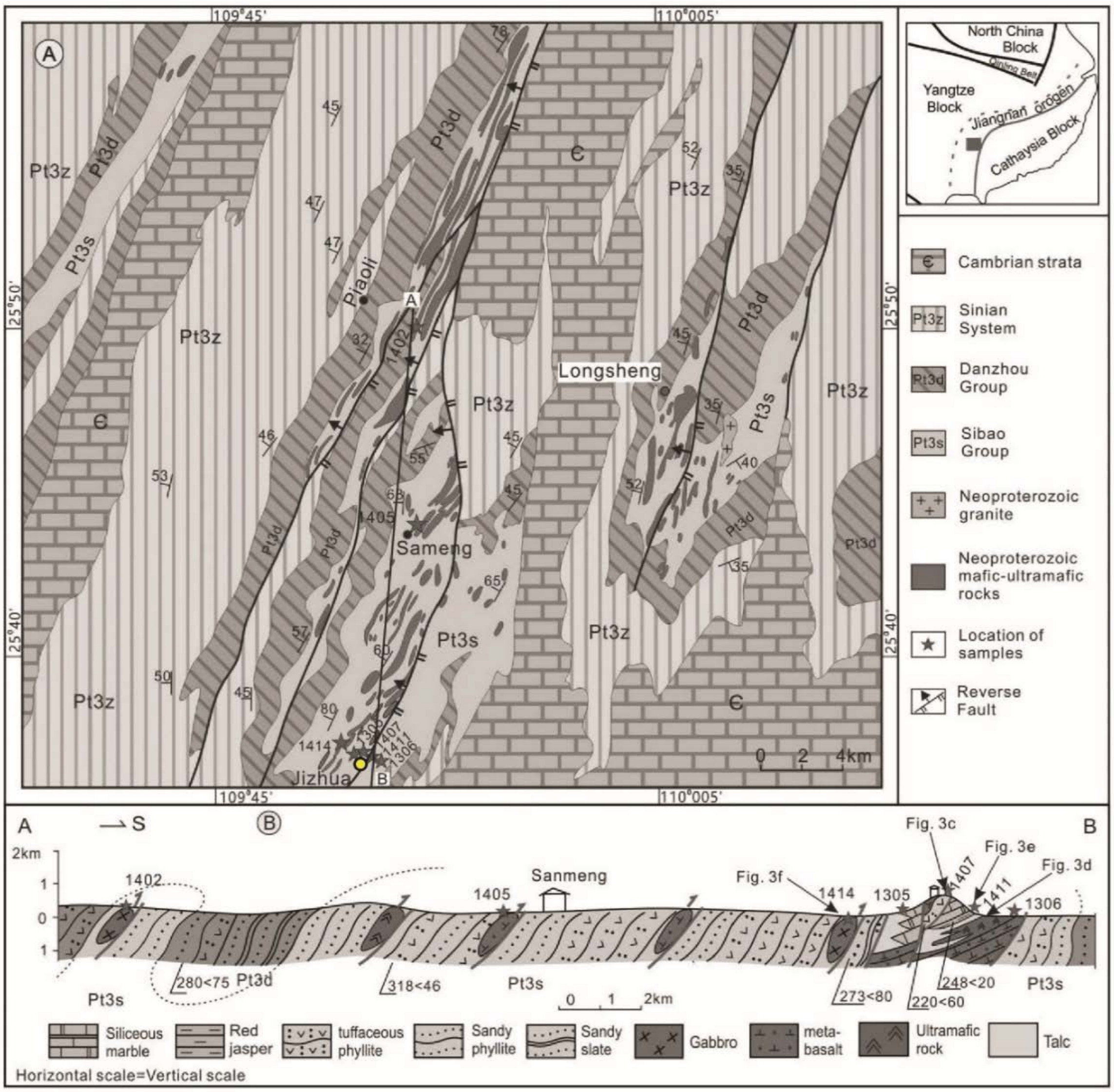


Figure 12. Geologic map from Yao et al. (2016) showing location of Jizhua (yellow dot) in Longsheng County, Guangxi Province, China. Talc deposits used in Johnson's Baby Powder and Shower to Shower are within the Danzhou Group.

Based on U-Pb zircon radiometric age constraints, the Danzhou Group was deposited sometime in the Neoproterozoic in a rift environment (Yao et al., 2016). Metamorphic mineral assemblages in the mafic rocks (e.g., albite, actinolite) indicate that the maximum grade of metamorphism experienced by the Danzhou Group hosting the talc deposits is greenschist-facies (medium pressure and maximum temperatures up to ~500°C; Figure 6). The talc deposits are spatially associated with thrust faults, including ductile shear zones, that formed during a collisional orogeny ~490–400 million years ago (Zhao et al., 2018). Deformation and metamorphism in the presence of Si-rich and H_20 and CO_2-bearing fluids facilitated metasomatism of the dolomitic marbles adjacent to the metabasalts to form the high-purity talc deposits (Li, 1979; Yao et al., 2016). Modeling of the metamorphic reactions indicates that some Mg needed to form the high-purity talc ores was supplied by the mafic rocks adjacent to the ore bodies (Li, 1979).

The descriptions of the geology and conditions of metamorphism in the published literature are consistent with that in the IMERYS413792 report for the Jizhua, Tongzishan, Guping, and Shanglang mines. While non-asbestiform tremolite and actinolite are reported in metabasalts (spillite) adjacent to the talc deposits by Li (1979) and IMERYS413792, respectively, none of the sources cited above detail any asbestiform minerals associated with the Longsheng talc deposits in the Danzhou Group, and there is no petrologic reason to predict the presence of asbestos.

6.0 Conclusions

Based on my knowledge of petrologic systems, extensive searching and evaluation of the published scientific literature, and examination of limited industry reports, it is my opinion to a reasonable degree of scientific certainty that the cosmetic talc sources used for Johnson's Baby Powder and Shower to Shower were limited to mines that were free of asbestiform minerals. Overwhelmingly, the data I have evaluated and described above weighs in favor of the conclusion that there is no scientific merit to any claims of asbestos in the cosmetic talc ores utilized. Based on reviews of the geology associated with the mines and the pressure and temperature histories recorded by the rocks, the amphiboles found in Johnson's Baby Powder and Shower to Shower derived from the Fontane, southern Vermont, and Guangxi talc mines would be incidental cleavage fragments from non-asbestiform amphiboles (i.e. prismatic or acicular), most likely derived from the margins (blackwall zones) of the talc deposits. Any such cleavage fragments are, in general, much less chemically-resistant and have different surface chemistries from their asbestiform counterparts, for which other distinctive properties include flexible bundles of fibrils with high tensile strength.

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Expert Report of Alan Campion, PhD (November 16, 2018)

Expert Report of Robert B. Cook, PhD (November 16, 2018)

Amended Expert Report of Robert B. Cook, PhD (January 22, 2019)

Robert Cook Deposition (January 30, 2019)

Expert Report of Mark Krekeler, PhD (November 16, 2018)

Addendum to the Expert Report of Mark Krekeler, PhD (January 17, 2019)

Mark Krekeler Deposition (January 25, 2019)

Expert Report of William E. Longo, PhD and Mark W. Rigler, PhD (November 14, 2018)

Supplementary Expert Report of William E. Longo, PhD & Mark W. Rigler, PhD (January 16, 2019)

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EXHIBIT A

Dr. Laura E. Webb

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EDUCATION

PhD in Geological and Environmental Sciences, Stanford University, Stanford, California, 1999. Doctoral Dissertation: "Exhumation of high and ultrahigh-pressure rocks in the Qinling–Dabie Orogen, eastern China and the Yagan–Onch Hayrhan metamorphic core complex, southern Mongolia." M.O. McWilliams, advisor. W.G. Ernst, S.A. Graham, and B.R. Hacker (UCSB), committee members.

BS in Geology, University of California, Los Angeles, *cum laude*, 1994.

APPOINTMENTS

Associate Professor, Department of Geology, University of Vermont, Burlington, Vermont, Fall 2014–present.

Assistant Professor, Department of Geology, University of Vermont, Burlington, Vermont, 2008–2014.

Graduate Faculty, University of Vermont, Burlington, Vermont, 2009–present.

PREVIOUS RESEARCH AND WORK EXPERIENCE

Research Assistant Professor, Department of Earth Sciences, Syracuse University, Syracuse, NY, 2004–2012.

Syracuse University Noble Gas Isotopic Research Laboratory Manager, Department of Earth Sciences, Syracuse University, Syracuse, NY, 2000–2008.

$^{40}Ar/^{39}Ar$ Laboratory Manager, University of Geneva, Switzerland, 1999–2000.

Staff Geologist, American Geotechnical, Anaheim, California, 1994.

AWARDED GRANTS AND CONTRACTS

2018–2021, DMR 1828371, National Science Foundation Major Research Instrumentation, $480,000: “MRI: Acquisition of a Variable-Pressure, Field-Emission Scanning Electron Microscope for Materials Research and Education” **Co-PI**. Collaborative with M. White (PI), C. Landry, R. Headrick, and F. Sansoz.

2016–2017, University of Vermont, College of Arts and Sciences, Seed Grant, $9843, Subduction–Exhumation History of the Tillotson Peak Complex, Vermont.” **PI.**

2010–2015, EAR 1028991, NSF Instrumentation and Facilities, $507,978: “Acquisition of a noble gas mass spectrometer and development of a multi-user facility for $^{40}Ar/^{39}Ar$ geochronology at the University of Vermont.” **PI**.

2010–2014, EAR 0948529, NSF Petrology and Geochemistry and co-sponsored by Tectonics, $194,493: “Collaborative Research: Constraining P-T-t-D paths of metamorphic tectonites

with the TitaniQ thermobarometer." **PI**. Collaborative research with F. Spear and J. Thomas (Rensselaer Polytechnic Institute).

2007–2014, EAR 0709054, NSF Continental Dynamics, $1,282,742: "Collaborative Research: How Is Rifting Exhuming the Youngest HP/UHP Rocks on Earth?" **Co-PI**. Collaborative with S. Baldwin (PI) and P. Fitzgerald (Syracuse University). Collaborative research with G. Abers, T. Plank, W.R. Buck & J. Gaherty (Columbia University), B. Hacker (UCSB), and P. Mann & B. Horton (UT Austin).

2009–2013, DUE 0941255, NSF Course Curriculum and Laboratory Improvement Program, $103,410: "Collaborative Research: Field-based Projects Exploring Geophysical Methods, with Applications to the State of Vermont." **PI**. Keith Klepeis, Co-PI. Collaborative research with D. Westerman and G. Springston (Norwich University; and the Vermont Geological Survey).

2006–2011, EAR 0537165 & EAR-0929902, NSF Tectonics, $267,223: "Collaborative Research: Strike-Slip History of the East Gobi Fault Zone, Mongolia: Modes of Intraplate Deformation, Sedimentary Basin Evolution, and Regional Fault Linkages". **PI.** Collaborative research with C. Johnson (University of Utah).

2004–2007, EAR 0345822, NSF Instrumentation and Facilities, $77,340: "Acquisition of an excimer laser system for Syracuse University Noble Gas Isotope Research Laboratory (SUNGIRL)". **Co-PI** with S. Baldwin.

TECHNICAL EXPERTISE

Nu Noblesse, MAP 216 and Micromass 5400 noble gas mass spectrometers for $^{40}Ar/^{39}Ar$ thermochronology.

Balzers Prisma QME 200 quadrupole mass spectrometer for (U-Th)/He thermochronology.

Design, construction, and maintenance of ultra-high vacuum extraction lines.

Management of radioactive materials and isotopic inventories.

Other analytical experience: electron microprobe analyses, secondary ionization mass spectrometry, laser ablation inductively couple mass spectrometry, cathodoluminescence imaging.

CONSULTING EXPERIENCE

2017–present: Formation of high-purity talc deposits mined for Johnson & Johnson talcum powders and their relationships, or lack thereof, to asbestos. Retained by law firms representing Johnson & Johnson in talc-related litigation.

COURSES REGULARLY TAUGHT AT UVM

*Denotes new courses at UVM developed by Webb

GEOL 161 Field Methods in Geophysics*. As of fall 2015, this is a recognized service-learning course and fulfills the University-wide sustainability general education requirement.

GEOL 231 Petrology

GEOL 240 Tectonics

GEOL 263 Geochronology*

GEOL 266 Microstructures*

GEOL 302 Introduction to Graduate Studies

INTERNATIONAL GEOLOGIC FIELD CAMPAIGNS

2011: Coastal batholith, Central Chile.
2010: Islands of the Woodlark Rise, southeastern Papua New Guinea.
2009: East Gobi Fault Zone, southern Mongolia.
2009: Louisiade Archipelago, southeastern Papua New Guinea.
2008: D'Entrecasteaux Islands, southeastern Papua New Guinea.
2004, 2006, 2007: East Gobi Fault Zone, southern Mongolia.
2002: Sulu ultrahigh-pressure terrane, Shandong peninsula, China.
1997, 1998: Southern Mongolia.
1994, 1995, 1996: Qinling–Dabie orogen, China.

HONORS, AWARDS AND PROFESSIONAL AFFILIATIONS

Member of: Geological Society of America, Mineralogical Society of America, American Geophysical Union, Vermont Geological Society, and American Association for the Advancement of Science.

Nominated for the 2018 Kroepsch-Maurice Excellence in Teaching Award at the associate professor level, University of Vermont.

2018 Awardee of "Outstanding New Service-Learning Faculty", Community-University Partnerships & Service-Learning (CUPS). Nominated for GEOL161 Field Methods in Geophysics course.

UVM Faculty Fellow for Service Learning, AY2014–2015. Participant in service learning workshops and working towards UVM designation of GEOL161 Field Methods in Geophysics as a service-learning course.

Featured in an article on NSF-funded research on titanium-in-quartz thermobarometry in *International Innovation*. "Under Pressure", *International Innovation*, North America, August 2012, Issue 3, pp. 120–122.

UVM Sustainability Faculty Fellow, 2012. Participant in program designed to foster integration of interdisciplinary approaches to sustainability into the UVM curriculum; enhance the understanding of sustainability concepts among those not trained in environmental fields; and to explore curriculum design strategies that will engage students in thinking about sustainability from a multidisciplinary perspective.

Nominated for the 2011 Kroepsch-Maurice Excellence in Teaching Award at the assistant professor level, University of Vermont.

PROFESSIONAL DEVELOPMENT AND WORKSHOPS

Participant in Scholarship of Teaching and Learning initiative (AY2017–2018). Development of Action Research project related to revision of GEOL 240 Tectonics course employing scaffolding approaches to facilitate student achievement of writing and information learning outcomes for Geology.

Designing for Learning Spring 2017 Cohort, University of Vermont. Participated in semester-long program for faculty to help identify and reduce student barriers to learning.

Co-convener of EarthScope synthesis workshop, *Synthesizing EarthScope Results: Develop a New Model for the 4-D Evolution of North America*, James Madison University, Harrisonburg, Virginia, November 2016.

Participant and breakout group synthesizer in the NSF-sponsored *Future of Tectonics Workshop*, University of Wisconsin, Madison, Wisconsin, May 2016.

Campuses for Environmental Stewardship, Faculty Development Institute and Training. November 5-6, 2015, Portland, Maine. Part of UVM team for development of sustainability service learning courses (participant in UVM subgrant from Maine Campus Compact project funded by the Davis Educational Foundation).

Participant in UVM Honors College Faculty Seminar, August 11–13, 2014: *'Big Data': Engaging and Critiquing the Production of Knowledge in the Digital Age*.

Outcomes of the Future of Geoscience Undergraduate Education Summit webinar participant, March, 2013.

EarthCube domain end-user workshop: Bringing Geochronology into the EarthCube framework. October, 2013, University of Wisconsin – Madison. Invited participant. The overall goal of the workshop is to: 1) identify the scientific challenges and opportunities facing the geochronology domain for next 5-15 years; 2) specify the data and cyber-infrastructure obstacles to meeting those challenges; 3) compile a list of known community data and modeling resources; 4) describe the data and cyber-capabilities required to meet challenges, by matching obstacles (2) with resources (3) and identifying/imagining unmet needs that may develop; and 5) develop ideas for at least two "proof-of-concept" projects or test cases for scientifically transformative activities that would become feasible if EarthCube is successful.

Systems, Society, Sustainability and the Geosciences Workshop. July 2012, Carleton College. This workshop is part of the InTeGrate project, a five-year, NSF-funded STEP Center grant geared towards increasing undergraduate geoscience literacy and "increase the number of majors in the geosciences and associated fields who are able to work with other scientists, social scientists, business people, and policy makers to develop viable solutions to current and future environmental and resource challenges."

Early Career Geoscience Faculty Workshop: Teaching, Research, and Managing Your Career. National Science Foundation On the Cutting Edge workshop series, College of William and Mary, 2008.

Participant in the NSF-funded *U.S.–Russia Workshop on the Plate Tectonic Evolution of Northeast Russia*. Stanford University, 2004.

Fourth International Symposium on Andean Geodynamics. University of Göttingen, Germany, 1999.

Exhumation Processes: Normal Faulting, Ductile Flow, and Erosion. Penrose Conference, Greece, 1996.

Ultrahigh-Pressure Metamorphism and Tectonics workshops. Stanford University, 1994 and 1999.

PROFESSIONAL SERVICE AND EDUCATIONAL OUTREACH

National Science Foundation EarthScope Steering Committee, member. Fall 2015–present.

Member of the UVM General Education Sustainability Assessment Committee, Spring 2016–Present. Co-Chair of committee during AY2017–2018 and AY2018–2019.

Member of the Standard Four: Academic Program Committee for UVM's 10-year reaccreditation review from the New England Association of Schools and Colleges (NEASC) in 2019, AY2017–2018.

Session organizer and convener, "Orogenic Sutures—Recognition, Characterization, and Tectonic Implications". Geological Society of America Northeastern Section Annual Meeting, Burlington, Vermont, March 2018.

Appointee to three-year term on the College of Arts and Sciences Deans Academic Planning and Budget Committee, Fall 2014–Spring 2017.

Co-convener of NSF EarthScope synthesis workshop: Synthesizing EarthScope Results to Develop a New Community Model for the 4-D Evolution of North America. November 18–20, 2016, at James Madison University, Harrisonburg, Virginia.

Department of Geology liaison for the Writing and Information Literacy in the Disciplines (WILD) General Education initiative, Spring 2014–Fall 2016.

Rock Point Funding and Staffing Committee, Land Use Implementation Plan, Spring 2015–2016.

Session organizer and convener, "Bridging Two Continents: Comparative Studies of Accretionary Orogenesis in the Central Asian Orogenic Belt, North American Cordillera, and Other Orogenic Belts". Joint meeting of the Geological Society of America (GSA) and the Geological Society of China (GSC), 2015 GSA Annual Meeting, Baltimore, Maryland, November 2015.

NSF EarthScope 2015 National Meeting organizing committee member. Stowe, Vermont, June 2015.

NSF EarthScope 2015 National Meeting organizer and co-leader of conference field trip. Stowe, Vermont, June, 2015.

Regular reviewer of NSF proposals (2–5 per year typical; Tectonics, Instrumentation and Facilities, Integrated Earth Systems, Petrology and Geochemistry, EarthScope, and CAREER programs) and journal manuscripts (5–10 per year typical. Journals include: *Geology, Tectonics, Journal of Metamorphic Geology, Terra Nova, GSA Bulletin, Journal of Structural Geology, Journal of Geology, Lithos, Journal of Geophysical Research – Solid Earth, Tectonophysics, Geoscience Frontiers, Journal of Asian Earth Sciences, Earth Science Reviews,* and *European Journal of Mineralogy*).

Department of Geology Graduate Student Coordinator, 2010–2013.

Organizer of Geology Seminar Series, Department of Geology, University of Vermont, 2009–2013.

Session organizer and convener, "Innovations in Geochronology: Present Developments and a Vision for 2020." 2013 Goldschmidt conference, Florence, Italy.

Member of the sustainability general education requirement committee charged with developing a suite of learning outcomes and methods of assessment for a university-wide sustainability general education requirement. 2013–2014.

UVM College of Arts and Sciences Academic Standing Committee, Fall 2010–Spring 2013.

Search committee member for Department of Geology tenure-track position in geochemistry, Spring 2013.

Earth Sciences proposal review panel member, National Science Foundation, Tectonics Program, served two single-term appointments in 2011 and 2012.

UVM College of Arts and Sciences summer orientation registration advising, 2009–2013.

Session organizer and convener, "The Wilson Cycle Revisited: From Microplates and Mobile Terranes to Supercontinent Dispersals." 2010 American Geophysical Union Fall Meeting.

Search Committee member for Department of Geology Chairperson, Spring 2010.

Faculty Senator, University of Vermont, 2009–2010.

Advisor to Geology Club and the Eta Kappa Chapter of the Sigma Gamma Epsilon National Honor Society for Earth Sciences, University of Vermont, 2009–2010.

Session organizer and convener, "Intraplate Deformation and Sedimentary Basins: A Record of Plate Margin Processes?" 2009 American Geophysical Union Fall Meeting.

UVM coordinator for the Vermont Geological Society Spring Meeting, April 2009.

Organizer of Geoscience Career Workshop, Department of Geology, University of Vermont, April 2009.

Session organizer and convener, "Microplate Geodynamics." 2008 American Geophysical Union Fall Meeting.

INVITED LECTURES

November 2018, Johns Hopkins University, "Insights into polyphase deformation and fault reactivation from $^{40}Ar/^{39}Ar$ geochronology."

April 2018, University of Miami Ohio, "Punctuated melt-enhanced deformation and tectonic reactivation above a long-lived subduction zone, Coastal Andes, Central Chile."

October 2016, University of Iowa, **"**Structural and isotopic constraints on the development of a major Phanerozoic intraplate fault zone**".**

February 2016, University of Wisconsin, Madison**,** "Slippery when wet: Confessions of an intraplate fault zone."

March 2015, University of Massachusetts, Amherst, "How to look older than your age: Phanerozoic life in the fastlane of the East Gobi Fault Zone."

October 2014, invited lecture on $^{40}Ar/^{39}Ar$ geochronology, Geological Society of America short course "EarthScope: Geochronology and the Earth Sciences", 2014 GSA Annual Meeting, Vancouver, Canada.

March 2012, McGill University GEOTOP Seminar, "The Epic Saga of Tavan Har: Phanerozoic Continental Growth, Collisional Orogenesis, and Intraplate Deformation in Southeastern Mongolia."

March 2012, University of New Hampshire Randolph W. Chapman Colloquium, "The Epic Saga of Tavan Har: Phanerozoic Continental Growth, Collisional Orogenesis, and Intraplate Deformation in Southeastern Mongolia."

September 2009, Department of Geology, Colby College, "P-T-t-D Paths of Metamorphic Tectonites and Making the Leap from Micron to Plate Scale."

October 2008, Department of Geology, Middlebury College, "Can subduction be undone? Examining the role of microplate rotation in the exhumation of high and ultrahigh-pressure rocks in Papua New Guinea."

April 2008, Syracuse University College of Arts and Sciences Frontiers of Science Lecture Series, "How do plate boundaries evolve on Earth?"

February 2008, Department of Geology, University of Vermont, "What's under the rug? Unraveling the tectonic history of southeastern Mongolia."

November 2006, Department of Geology & Geography, West Virginia University, "Unraveling complex intraplate deformation in southeastern Mongolia."

PUBLICATIONS IN PEER-REVIEWED JOURNALS

Student authors indicated in italics

Klepeis, K.A., **Webb, L.E.**, *Blatchford, H.*, Schwartz, J., Jongens, R., Turnbull, R., and Stowell, H., *in review*, Crust-mantle interactions above the Puysegur subduction zone in Fiordland, New Zealand. GSA Today.

Brombin, V., Bonadiman, C., Jourdan, F., Roghi, G., Coltori, M., **Webb, L.E.**, Callegaro, S., Bellieni, G., De Vecchi, G., Sedea, R., Marzoli, A., *in revision*, Intraplate magmatism at a convergent plate boundary, the case of the Cenozoic northern Adria magmatism. Earth-Science Reviews.

Webb, L.E., and Klepeis, K.A., *in press*, $^{40}Ar/^{39}Ar$ constraints on the Tectonic evolution of the Late Paleozoic and Early Mesozoic accretionary complex of coastal Central Chile. Book chapter *in* Horton, B., and Folguera, A. eds. Andean Tectonics; Elsevier.

Cordova, J.L., Mulcahy, S.R., Schermer, E.R., and **Webb, L.E.**, 2018, Subduction initiation and early evolution of the Easton Metamorphic Suite, Northwest Cascades, Washington. Lithosphere, v. 11, no. 1, p. 44-58, doi.org/10.1130/L1009.1.

Heumann, M.J., Johnson, C.L., **Webb, L.E.**, 2017, Plate interior polyphase fault systems and sedimentary basin evolution: Case study of the East Gobi Basin and East Gobi Fault Zone, southeastern Mongolia, Journal of Asian Earth Sciences, v. 151, p. 343–358, doi: 10.1016/j.jseaes.2017.05.017.

Webber, J.R., Klepeis, K.A., **Webb, L.E.**, Cembrano, J., Morata, D., Mora-Klepeis, G., and Arancibia, G., 2015, Deformation and magma transport in a crystallizing plutonic complex, Coastal Batholith, central Chile, Geosphere, v. 11, no. 5., p. 1401-1426.

Webb, L.E., Baldwin, S.L. and Fitzgerald, P.G., 2014, The Early–Middle Miocene subduction complex of the Louisiade Archipelago, southern margin of the Woodlark Rift. Geophysics, Geochemistry, Geosystems, doi: 10.1002/2014GC005500.

Heumann, M.J., Johnson, C.L., **Webb, L.E.**, *Taylor, J.P.*, Jalbaa, U., and Minjin, C., 2014, Total and incremental left-lateral displacement across the East Gobi Fault Zone, southern Mongolia: implications for timing and modes of polyphase intracontinental deformation, Earth and Planetary Science Letters, v. 392, p. 1-15, doi: 10.1016/j.epsl.2014.01.016.

Ashley, K.T., **Webb, L.E.**, Spear, F.S., and Thomas, J.B., 2013, P-T-D histories from quartz: A case study of the application of the TitaniQ thermobarometer to progressive fabric development in metapelites, Geochemistry, Geophysics, Geosystems, v. 14, doi: 10.1002/ggge.20237.

Taylor, J., **Webb, L.**, Johnson, C., and *Heumann, M.*, 2013, The lost South Gobi Microcontinent: protolith studies of metamorphic tectonites and implications for the evolution of continental crust in southeastern Mongolia, Geosciences, special issue: Continental Accretion and Evolution, doi:10.3390/geosciences3030543.

Leech, M.L., and **Webb, L.E.**, 2013, Is the HP-UHP Hong'an-Dabie-Sulu orogen a piercing point for offset on the Tan-Lu fault? Journal of Asian Earth Sciences, v. 62, p. 112–129, DOI: 10.1016/j.jseaes.2012.08.005.

Spear, F., *Ashley, K.T.*, **Webb, L.E.**, and Thomas, J., 2012, Ti diffusion in quartz inclusions: implications for metamorphic time scales, Contributions to Mineralogy and Petrology, DOI: 10.1007/s00410-012-0783-z.

Baldwin, S.L., Fitzgerald, P.G., and **Webb, L.E.**, 2012, Tectonics of the New Guinea region, Annual Review of Earth and Planetary Sciences, v. 40, p. 495-520, doi: 10.1146/annurev-earth-040809-15254, ***INVITED***.

Heumann, M.J., Johnson, C.L., **Webb, L.E.**, *Taylor, J.P.*, Jalbaa, U., and Minjin, C., 2012, Paleogeographic reconstruction of a late Paleozoic arc collision zone, southern Mongolia, Geological Society of America Bulletin, doi:10.1130/B30510.1.

Webb, L.E., Johnson, C.L., and Minjin, C., 2010, Late Triassic sinistral shear in the East Gobi Fault Zone, Mongolia, Tectonophysics, v. 495, p. 246-255, doi: 10.1016/j.tecto.2010.09.033.

Webb, L.E., Baldwin, S.L., Little, T.A., and Fitzgerald, P.G., 2008, Can microplate rotation drive subduction inversion? Geology, v. 36, p. 823–826.

Baldwin, S.L., **Webb, L.E.**, and Monteleone, B.D., 2008, Late Miocene coesite-eclogite exhumed in the Woodlark Rift, Geology, v. 36, p. 735–738.

Monteleone, B.D., Baldwin, S.L., **Webb, L.E.**, Fitzgerald, P.G., Grove, M., and Schmidt, A.K., 2007, Late Miocene–Pliocene eclogite-facies metamorphism, D'Entrecasteaux Islands, SE Papua New Guinea, Journal of Metamorphic Geology, v. 25, p. 245–265.

Webb, L.E., and Johnson, C.L., 2006, Tertiary strike-slip faulting in southeastern Mongolia and implications for Asian tectonics, Earth and Planetary Science Letters, v. 241, p. 323–335.

Webb, L.E., Leech, M.L., and Yang, T., 2006, $^{40}Ar/^{39}Ar$ thermochronology of the Sulu terrane: Late Triassic exhumation of high and ultrahigh-pressure rocks and implications for Mesozoic tectonics in East Asia, *in* Geological Society of America Special Paper *Ultrahigh-Pressure Metamorphism: Deep Continental Subduction,* edited by B.R. Hacker, B. McClelland, and J.G. Liou, p. 77–92.

Leech, M.L., **Webb, L.E.**, and Yang, T., 2006, Diachronous histories for the Dabie-Sulu orogen from high-temperature geochronology, *in* Geological Society of America Special Paper *Ultrahigh-Pressure Metamorphism: Deep Continental Subduction,* edited by B.R. Hacker, B. McClelland, and J.G. Liou, p. 1–22.

Lewis, A.R., Marchant, D.R., Baldwin, S.L., and **Webb, L.E.**, 2006, The age and origin of the Labyrinth, western Dry Valleys, Antarctica: evidence for extensive middle Miocene subglacial floods and freshwater discharge to the Southern Ocean, Geology, v. 34, p. 513–516.

Fitzgerald, P., Baldwin, S., **Webb, L.E.,** and O'Sullivan, P., 2006, Interpretation of (U-Th)/He single grain ages from slowly cooled crustal terranes: A case study from the Transantarctic Mountains of southern Victoria Land, Chemical Geology, v. 225, p. 91–120.

Baldwin, S.L., *Monteleone, B.*, **Webb, L.E.**, Fitzgerald, P.G., Grove, M and Hill, E.J., 2004, Pliocene eclogite exhumation at plate tectonic rates in eastern Papua New Guinea, Nature, v. 431, p. 263–267.

Ratschbacher, L., Hacker, B.R., Calvert, A., **Webb, L.E.**, Grimmer, J.C., McWilliams, M., Ireland, T.R., Dong, S. and Hu, J., 2003, Tectonics of the Qinling (central China): Tectonostratigraphy, geochronology, and deformation kinematics, Tectonophysics, v. 336, p. 1–53.

Johnson, C.L., **Webb, L.E.**, Graham, S.A., Hendrix, M., and Badarch, G., 2001, Sedimentary and structural records of late Mesozoic high-strain extension and strain partitioning, East Gobi Basin, southern Mongolia, Memoir - Geological Society of America, v. 194, p. 231–246.

Webb, L.E., Ratschbacher, L., Hacker, B.R. and Dong, S., 2001, Kinematics of exhumation of high- and ultrahigh-pressure rocks in the Hong'an and Tongbai Shan of the Qinling–Dabie collisional orogen, eastern China, Memoir - Geological Society of America, v. 194, p. 413–434.

Graham, S.A., Hendrix, M.H., Johnson, C.L., D. Badamgarav, G. Badarch, Amory, J., Porter, M., R. Barsbold, **Webb, L.E.**, Hacker, B., 2001, Sedimentary record and tectonic implications of Mesozoic rifting in southeast Mongolia, GSA Bulletin, v. 113, p. 1560–1579.

Hacker, B.R., Ratschbacher, L., **Webb, L.E.**, McWilliams, M., Calvert, A., Dong, S., Wenk, H.-R., and Chateigner, D., 2000. Exhumation of ultrahigh-pressure rocks in the Dabie-Hong'an area: Late Triassic-Early Jurassic tectonic unroofing, Journal of Geophysical Research, v. 105, p. 13,339–13,364.

Ratschbacher, L., Hacker, B.R., **Webb, L.E.**, Calvert, A., Ireland, T.R., McWilliams, M.O., Dong, S., Chateigner, D., and Wenk, H.-R., 2000. Exhumation of the ultrahigh-pressure continental crust in east-central China: Cretaceous and Cenozoic unroofing and the Tan-Lu Fault, Journal of Geophysical Research, v. 105, 13303–13338.

Lamb, M.A., Hanson, A.D., Graham, S.A., Badarch, G., and **Webb, L.E.**, 1999, Left-lateral sense offset of Upper Proterozoic and Paleozoic features on the Gobi Onon, Tost, and Zuunbayan faults in southern Mongolia and implications for other central Asian faults, Earth and Planetary Research Letters, v. 173, p. 183–194

Webb, L.E., Hacker, B.R., Ratschbacher, L., Michael O. McWilliams, and Dong S., 1999. Thermochronologic constraints on deformation and cooling history of high and ultrahigh-pressure rocks in the Qinling–Dabie orogen, Tectonics, v. 18, p. 621–638.

Webb, L.E., Graham, S.A., Johnson, C.L., Badarch, G., Hendrix, M., 1999. Occurrence, age, and implications of the Yagan–Onch Hayrhan metamorphic core complex, southern Mongolia, Geology, v. 27, p. 143–146.

Hacker, B.R., Ratschbacher, L., **Webb, L.E.**, Ireland, T., Walker, D., and Dong S., 1998. U/Pb Zircon ages constrain the architecture of the ultrahigh-pressure Qinling–Dabie orogen, China, Earth and Planetary Science Letters, v.161, p. 215–230.

Hacker, B.R., Ratschbacher, L., **Webb, L.E.**, and Dong S., 1995. What brought them up? Exhumation of the Dabie Shan ultrahigh-pressure rocks, Geology, v. 23, p. 743–746.

WHITE PAPERS

Crespi, J., Klepeis, K., Williams, M., Thomas, W., **Webb, L.**, Gale, M., Kim, J., and Becker, L., 2011, EarthScope in the New England Appalachians: Structural inheritance and the long-term strength of continental lithosphere. National Science Foundation Joint EarthScope-GeoPRISMS Science Workshop for Eastern North America.

Baldwin, S., Fitzgerald, P., Curewitz, D., Mann, P., Hacker, B., **Webb, L.**, Abers, G., Little, T., Wallace, L., Devey, C., Hoernle, K., Speckbacher, R., and Behrmann, J., 2010, Rift Initiation and Evolution within an Active Plate Boundary Zone: The Woodlark Rift of Papua New Guinea. National Science Foundation GeoPRISMS Rift Initiation and Evolution (RIE) initiative.

PUBLISHED (REFERREED) ABSTRACTS OF CONFERENCE PRESENTATIONS

Student authors indicated in italics

Webb, L.E., 2019. Revelations from EarthScope on the Dynamic History of North America. Association for the Advancement of Science, Annual Meeting, Washington D.C. ***INVITED.***

McGrew, A.J., *Rodgers, A.*, Metcalf, J.R., Mesiner, C.B., and **Webb, L.E.**, 2018. Tracking the escalator ride from mid-crustal depths to the surface: New constraints on the pace and episodicity of late Eocene to Miocene exhumation from the southern east Humboldt Range

metamorphic core complex, Elko County, Nevada. Geological Society of America Abstracts with Programs. Vol. 50, No. 6. doi: 10.1130/abs/2018AM-318419.

Baldwin, S.L., Fitzgerald, P.G., **Webb, L.E.**, Malusa, M.G., and Moucha, R., 2018. How to make and exhume (U)HP terranes: insights from southeastern Papua New Guinea (EOS, Transactions, American Geophysical Union, Fall Meeting). ***INVITED.***

Gonzalez, J., Baldwin, S.L., Thomas, J.B., Fitzgerald, P.G., **Webb, L.E.**, and Kim, J.J., 2018. Peak pressure-temperature-time estimates for Taconic orogen high-pressure rocks, Tillotson Peak Complex, Vermont. (EOS, Transactions, American Geophysical Union, Fall Meeting).

Tam, E., Webb, L.E., and *Aiken, C.*, 2018. Geochronologic Constraints on the Timing of Deformation in the Footwall of the Prospect Rock Fault in North-Central Vermont. Geological Society of America Abstracts with Programs. Vol. 50, No. 2, doi: 10.1130/abs/2018NE-310928.

Caswell, B., Gilotti, J.A., Webb, L.E., Jones, D.A., McClelland, W.C., 2018. $^{40}Ar/^{39}Ar$ Geochronology of Biotite from Ductile Shear Zones of the Ellesmere-Devon Crystalline Terrane, Nunavut, Canadian Arctic. Geological Society of America Abstracts with Programs. Vol. 50, No. 2, doi: 10.1130/abs/2018NE-310455

Dundas, E., Ehlers, A., Lee, J., Titsworth, K., Weiss, H., and **Webb, L.E.**, 2018. Use of Ground-Penetrating Radar and Electromagnetic Induction Profiling to Image a Buried Revolutionary War Trench at Chimney Point, Addison County, Vermont. Geological Society of America Abstracts with Programs. Vol. 50, No. 2, doi: 10.1130/abs/2018NE-311041.

Aiken, C.L., and **Webb, L.E.**, 2018. Geochronologic Constraints on the Timing of Metamorphism and Exhumation of the Tillotson Peak Complex in Northern Vermont. Geological Society of America Abstracts with Programs. Vol. 50, No. 2, doi: 10.1130/abs/2018NE-310829.

Webb, L.E., Klepeis, K.A., and Kim, J.J., 2018. New Insights on Acadian Deformation and Reactivation in Northern Vermont from Integrated Structural and Geochronological Studies. Geological Society of America Abstracts with Programs. Vol. 50, No. 2, doi: 10.1130/abs/2018NE-311032.

Klepeis, K., **Webb, L.E.**, *Merson, M.Q.*, and Kim, J.J., 2018. Unraveling Fault Reactivations and Their Tectonic Significance Using Integrated Structural Data and $^{40}Ar/^{39}Ar$ Geochronology, Examples from N. Vermont and S.W. New Zealand. Geological Society of America Abstracts with Programs. Vol. 50, No. 2, doi: 10.1130/abs/2018NE-311301.

Maguire IV, H.C., Merhtens, C., Chiarenzelli, J., and Webb, L.E., 2018. Detrital Zircon Ages for the Cambrian Monkton and Danby Formations, Champlain Valley, Vermont. Geological Society of America Abstracts with Programs. Vol. 50, No. 2, doi: 10.1130/abs/2018NE-311008.

Gonzalez, J.P., Baldwin, S., Kim, J.J., and **Webb, L.E.**, 2018. A Comparison of Pressure-Temperature-Time Histories across the Burgess Branch Fault Zone, Northern Vermont. Geological Society of America Abstracts with Programs. Vol. 50, No. 2, doi: 10.1130/abs/2018NE-310874.

Brombin, V., Marzoli, A., Roghi, G., Fred, J., Coltorti, M., Bonadiman, C., **Webb, L.E.**, Sara, C., Giuliano, B., De Vecchi, G. and Roberto, S., 2018. The temporal evolution of the Cenozoic Southalpine magmatic activity in North-East Italy: evidence from $^{40}Ar/^{39}Ar$ geochronology. In European Geosciences Union (pp. 1-1). European Geosciences Union.

Tam, E., **Webb, L.E.**, and *Aiken, C.L.*, 2017, Role of the Prospect Rock Fault in the Exhumation of High Pressure Rocks in North-Central Vermont. (EOS, Transactions, American Geophysical Union).

Klepeis, K., **Webb, L.E.**, Blatchford, H.J., Schwartz, J.J., Turnbull, R., and Jongens, R., 2017. Unraveling a history of repeated fault reactivations and differential uplift above a young subduction zone in SW New Zealand, Geological Society of America Abstracts with Programs. Vol. 49, No. 6, doi: 10.1130/abs/2017AM-306155.

Webb, L.E., 2017. Strange results or: How I learned to stop worrying and love complicated $^{40}Ar/^{39}Ar$ apparent age spectra. Geological Society of America Abstracts with Programs. Vol. 49, No. 6, doi: 10.1130/abs/2017AM-306106.

Cordova, J.L., Schermer, E., Mulcahy, S.R., and **Webb, L.E.**, 2017. Initiation and early evolution of a subduction zone: T-t-D history of the Easton metamorphic suite, northwest Washington State, Geological Society of America Abstracts with Programs. Vol. 49, No. 6, doi: 10.1130/abs/2017AM-303853.

Fitzgerald, P.G., Baldwin, S.L., Bermúdez, M.B., **Webb, L.E.**, Little, T.A., Miller, S.R., Malusà, M.G., Seward, D., 2017. Rift-triggered exhumation of eclogite-bearing gneiss domes in eastern Papua New Guinea: Geologic and thermochronologic constraints. 12th International Eclogite Conference, Åre, Sweden, August 2017.

Aiken, C., and **Webb, L.E.**, 2017. Exhumation of the Tillotson Peak complex in northern Vermont. Northeastern North-Central Joint Section Meeting of the Geological Society of America. Pittsburgh, Pennsylvania.

Brombin, V., **Webb, L.**, Bonadiman, C., Marzoli, A., and Coltorti, M., 2017. A geochronological study of mafic and acidic lavas from Veneto Volcanic province (North-East Italy), EGU General Assembly 2017, Vienna, Austria. Geophysical Research Abstracts, Vol. 19, EGU2017-6410, 2017.

Ebinger, C., Humphreys, E., Williams, M., van der Lee, S., Levin, V., **Webb, L.**, and Becker, T., 2017. Dynamics and the Wilson Cycle: An EarthScope vision. EGU General Assembly 2017, Vienna, Austria. Geophysical Research Abstracts, Vol. 19, EGU2017-5829.

Webb, L.E., Klepeis, K.A., Kim, J., and *Sullivan, P.*, 2017, Reactivation of Taconic Thrust Faults in the Late Acadian Orogenic Front. 2017 EarthScope National Meeting. Anchorage, Alaska.

Mehrtens, C., **Webb, L.E.**, Harrington, S., Desanto, D., and Berman, E., 2016. Writing and Information Literacy in The Geosciences: A Pilot Project to Improve Student Understanding and Communication, Geological Society of America Abstracts with Programs. Vol. 48, No. 7, doi: 10.1130/abs/2016AM-277481.

Tsai, C.-H., Liu, C., **Webb, L.**, and Keyser, W., 2016, New P-T and Geochronological Constraints on High-Pressure Garnet-Bearing Paragonite-Epidote Amphibolite in the Yuli Belt, Eastern Taiwan. Goldschmidt Conference, Yokohama, Japan. Goldschmidt Abstracts, 2016 3180.

Webb, L.E and Klepeis, K.A., 2015, Punctuated melt-enhanced deformation and tectonic reactivation above a long-lived subduction zone, coastal Andes, central Chile, Geological Society of America Abstracts with Programs. Vol. 47, No. 7, p. 495.

Baldwin, S.L., Malusà, M.G., Fitzgerald, P.G., **Webb, L.E.**, and, 2015, Deciphering the 4-d evolution of Cenozoic (U)HP terranes, Geological Society of America Abstracts with Programs. Vol. 47, No. 7, p. 168. ***INVITED***.

Fitzgerald, P.G., Baldwin, S.L., Bermúdez, M.B., **Webb, L.E.**, Little, T.A., Malusà, M.G., Miller, S.R., and Seward, D., 2015, Constraints from low-temperature thermochronology on exhumation of (U)HP terranes: the eastern Papuan New Guinea example, Geological Society of America Abstracts with Programs. Vol. 47, No. 7, p. 375.

Lagor, S. and **Webb, L.E.**, 2015, Evidence for syntectonic intrusion of the Knox Mountain Pluton in the Connecticut Valley-Gaspe Trough, central Vermont, Geological Society of America Abstracts with Programs. Vol. 47, No. 3, p. 101.

Baldwin, S.L., Fitzgerald, P.G., **Webb, L.E.**, and Malusà, M.G., 2015, The (U)HP terrane of eastern Papua New Guinea: a modern analogue for (U)HP terranes globally, XI International Eclogite Conference, Dominican Republic.

Fitzgerald, P.G., Baldwin, S.L., Bermúdez, M.B., **Webb, L.E.**, Little, T.A., Miller, S.R., Malusà, M.G., and Seward, D., 2014, Exhumation of the Papuan New Guinea (U)HP terrane: Constraints from low temperature thermochronology, XI International Eclogite Conference, Dominican Republic.

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Fitzgerald, P.G., Baldwin, S.L., Miller, S.R., Little, T.A., **Webb, L.E.**, Metcalf, J.R., and Perry, S.E., 2011, Apatite fission track and (U-Th)/He dating in the world's youngest UHP terrane: The Woodlark rift of southeastern Papuan New Guinea, Mineralogical Magazine, p. 852.

Webb, L.E., *Taylor, J.P., Heumann, M.J.*, Johnson, C.L., *Stypula, M.J.*, and *Hagen-Peter, G.A.*, 2010, Thermochronologic Records of Intraplate Deformation in the Northern East Gobi Fault Zone, Mongolia (EOS, Transactions, American Geophysical Union).

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Baldwin, S., *Zirakparvar, N.A., Catalano, J.P.*, Fitzgerald, P.G., **Webb, L.E.**, and Little, T., 2010, Reconstructing the Mid-Miocene to Recent evolution of the Woodlark Rift (EOS, Transactions, American Geophysical Union).

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Baldwin, S.L., **Webb, L.E.**, Fitzgerald, P.G, *Zirakparvar, N.A.*, and *Catalano, J.P.*, 2010, From subduction to rifting: The Late Cretaceous–Cenozoic tectonic evolution of eastern Papua New Guinea, (Tectonic Crossroads: Evolving Orogens of Eurasia-Africa-Arabia, Ankara, Turkey, Paper No. 32-3), ***INVITED***.

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Hendrix, M.S., Beck, M.A., Graham, S. A., Johnson, C. J., and **Webb, L.**, 1998, Early Mesozoic development of a regional lake system in southern Mongolia - sedimentary signature of a collisional foreland style basin? Yinshan-Yanshan major thrust and nappe structures field conference, May 8-11, Hohhot, Nei Mongol, China.

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Johnson, C.L., Graham, S.A., **Webb, L.E.**, Badarch, G., Hendrix, M., Sjostrom, D., Beck, M., and Lenegan, R., 1997. Sedimentary response to late Mesozoic extension in southern Mongolia (EOS, Transactions, American Geophysical Union; v. 78). *INVITED.*

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complex of southern Mongolia (EOS, Transactions, American Geophysical Union; v. 78). ***INVITED.***

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Webb, L.E., Hacker, B.R., Ratschbacher, L., and Dong S., 1996. Structures, and kinematics of exhumation; ultrahigh-pressure rocks in the Hong'an Block of Qinling–Dabie Orogen, China (Geological Society of America *Abstracts with Programs*, v. 28).

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Hacker, Bradley R., Ratschbacher, L., **Webb, L.E.**, and Dong S., 1995, What brought them up? Exhumation of ultrahigh-pressure rocks in the Dabie Mountains of eastern China. (EOS, Transactions, American Geophysical Union; v. 76).

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GRADUATE ADVISING

Kristin Schnalzer (BS SUNY Plattsburgh), University of Vermont, MS in Geology, 2020 expected. Investigating the timing of deformation in the Chester Dome with $^{40}Ar/^{39}Ar$ geochronology.

Cheyne Aiken (BS SUNY Potsdam), University of Vermont, MS in Geology, October 2018. Geochronologic Constraints on the Timing of Metamorphism and Exhumation of the Tillotson Peak Complex in Northern Vermont.

Evan Tam (BS University of Connecticut), University of Vermont, MS in Geology, October 2018. Geochronological Constraints on the Timing of Deformation: An Examination of the Prospect Rock Fault Footwall in North-Central Vermont.

Samuel Lagor (BS St. Lawrence University), University of Vermont, MS in Geology, May 2016. The relationship between magmatism, deformation, and metamorphism during the Acadian orogeny: A case study from the Knox Mountain pluton, Green Mountains, Vermont.

Patrick Dyess (BS Montana State University), University of Vermont, MS in Geology, October 2013. Interpreting Quartz Textures through TitaniQ Thermobarometry of Low Grade Metapelites, Northfield Mountains, Vermont. Went on to work with NTL Engineering and Geoscience, Inc.

Christine Downs (BS Salem State University), University of Vermont, MS in Geology, October 2012. The Characterization of Ductile Deformation in the Upper and Lower Plates of the Hinesburg Thrust Fault Through Detailed Geometric Analysis of Selected Outcrops. Currently a PhD student at University of Southern Florida.

Merril Stypula (BA Colorado College), University of Vermont, MS in Geology, May 2012. U-Pb Zircon Dating of Metamorphic Tectonites from Tavan Har, Southeast Mongolia: Implications for the Role of Tectonic Inheritance in Intraplate Shear Zones. Currently employed by EQT Corporation.

Kyle Ashley (BS SUNY Potsdam), University of Vermont, MS in Geology, October 2011. TitaniQ Thermobarometry of Fabric Development in the Strafford Dome, Vermont: Linking Microstructures to Orogenic Processes. Went on to a PhD program at Virginia Tech, post-doc at UT Austin, and now a visiting professor at University of Pittsburgh.

Joshua Taylor, (BS St. Lawrence University, MS Syracuse University), Syracuse University, PhD in Earth Sciences (co-advisor with P.G. Fitzgerald), May 2011. Tectonic History of the East Gobi Fault Zone, Southeastern Mongolia: An Integrated Study Using Structural Geology, Geochronology, and Thermochronology. Currently employed at ExxonMobil Exploration Company.

GRADUATE STUDENT THESIS COMMITTEES

John Mark Brigham, Syracuse University, Department of Earth Sciences. MS, 2019 expected. Mineralogy of the Partially Serpentinized Meta-Dunite in East Dover, Vermont. Advisor: Suzanne Baldwin.

Joseph Gonzales, Syracuse University, Department of Earth Sciences. PhD, 2019 expected. Petrology and Thermochronology of the Burgess Branch Fault Zone at the Tillotson Peak Complex, Vermont. Advisor: Suzanne Baldwin.

Caswell, Brandon, University of Idaho, MS, 2018. $^{40}Ar/^{39}Ar$ Geochronology of Biotite from Ductile Shear Zones of the Ellesmere-Devon Crystalline Terrane, Nunavut, Canadian Arctic. Advisor: Jane Gilotti.

Matthew Merson, University of Vermont, Department of Geology, MS, 2018. The Spatial and Temporal Development of the Champlain Thrust Fault Zone Exposed in Northwest Vermont. Advisor: Keith Klepeis.

Maquire IV, Henry, MS, 2018. Application of Geostatistical and Geochronological Methods to Stratigraphic Problems in the Lower Cambrian Monkton Formation. Advisor: Charlotte Mehrtens.

Julia Runcie, University of Vermont, Ecological Planning Program, Rubenstein School of Environment and Natural Resources. MS, 2017. Environmental assessment guiding recreation at Travertine Hot Springs ACEC. Advisor: Dean Wang

Gina Accorsi, University of Vermont, Department of Geology, MS, 2017. Geochemical and XRD fingerprinting of conflict minerals, Advisor: John M. Hughes.

Mike Ingram, University of Vermont, Department of Geology, MS, 2016. The Effects of Heterogeneity in the Lower Crust on Strain Partitioning and Fabric Development During Extension Doubtful Sound, New Zealand. Advisor: Keith Klepeis.

John Gilbert, University of Vermont, Department of Geology, MS, 2016 expected. Crustal deformation during arc-flare up magmatism: Field and microstructural analysis of a mid-crustal, melt-enhanced shear zone. Advisor: Keith Klepeis.

Hannah Blatchford, University of Vermont, Department of Geology, MS, 2016. Fiordland, New Zealand. The Structural Evolution of a Portion of the Median Batholith and Its Host Rock in Central Fiordland, New Zealand: Examples of Partitioned Transpression and Structural Reactivation. Advisor: Keith Klepeis.

Benjamin Melosh, McGill University, Department of Earth and Planetary Sciences, PhD, 2015. Earthquake cycling in the brittle-plastic transition of a transform boundary: The Pofadder Shear Zone, Namibia and South Africa. Advisor: Christie Rowe.

Myagmarjav Lkhagvasuren, University of Vermont, Wildlife and Fisheries Biology Program Rubenstein School of Environment and Natural Resources, MS, 2015. Effects of Landscape Characteristics on Carnivore Diversity in Mongolia. Advisor: James Murdoch.

Ryan Brink, University of Vermont, Department of Geology, MS, 2014. Sedimentologic Comparison of the Late/Lower Early Middle Cambrian Altona Formation and the Lower Cambrian Monkton Formation. Advisor: Char Mehrtens.

Kathryn Dianiska, University of Vermont, Department of Geology, MS, 2014. The Interplay Between Deformation and Metamorphism During Strain Localization in the Lower Crust: Insights from Fiordland, New Zealand. Advisor: Keith Klepeis.

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Jacob Menken, University of Vermont, Department of Geology, MS, 2014. Effect of Thermal Treatment on the Cation Exchange and Disordering in Tourmaline. Advisor: John Hughes.

Stephanie Perry, Syracuse University, Department of Earth Sciences, PhD, 2014. Thermotectonic Evolution of the Alaska Range: Low-temperature Thermochronologic Constraints. Advisor: Paul Fitzgerald.

Jeffrey Webber, University of Vermont, Department of Geology, MS, 2012. Advances in Rock Fabric Quantification and the Reconstruction of Progressive Dike Emplacement in the Coastal Batholith of Central Chile. Advisor: Keith Klepeis.

Jessica Terrien, Syracuse University, Department of Earth Sciences, PhD, 2012, dissertation in progress. Thermochronology and Geophysical Modeling of the Santa Catalina Metamorphic Core Complex, Arizona. Advisor: Suzanne Baldwin.

Charles Trodick, University of Vermont, Department of Geology, MS, 2011. Sediment Generation Rates in the Potomac River Basin. Advisor: Paul Bierman.

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Janelle McAtamney, University of Vermont, Department of Geology, MS, 2010. Synthesizing the tectonic evolution of the Magallanes foreland basin during the Late Cretaceous backarc basin inversion using structural and stratigraphic evidence from Bahia Brookes, southern Patagonia, Chile. Advisor: Keith Klepeis.

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ADVISING OF UNDERGRADUATE RESEARCH

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Samantha Portnoy, Geology BS, 2018. Relationship between rapid exhumation and fault patterns in Fiordland, New Zealand. Co-advising with Keith Klepeis.

Patrick Sullivan, University of Vermont, Geology BS, 2017. Structural analysis and geochronology of pseudotachylyte in the Taconic Arrowhead Mountain thrust fault zone.

Elizabeth Pidgeon, University of Vermont, Geology BS, 2017. Subduction–exhumation-related deformation of high-pressure rocks, Tillotson Peak, Vermont.

Mariah Schneider, University of Vermont, Geology, BS, 2016. Geo-archaeological investigation of the UVM Green using ground penetrating radar, electromagnetic induction, and seismic refraction profiling.

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Jacob Vincent, University of Vermont, Geology, BS, 2014. Structural analysis of Acadian deformation the Dog River Fault Zone, Montpelier, Vermont.

Stefan Christie, University of Vermont, Geology, BS, 2014. Geophysical investigation of the Kent Island Formation within the Blackwater National Wildlife Refuge and the potential influence of glacioisostatic adjustment on the Mid-Atlantic. This project is in collaboration with Ben DeJong, UVM PhD student.

Karina Heffernan, University of Vermont, Geology, BS, 2014. Geological and geophysical investigations of possible karst structures in the Dunham Dolomite, Starksboro, Vermont. This project is in collaboration with the Vermont Geological Survey.

Parker Richmond, University of Vermont, Geology, BS, 2013. Ground-penetrating radar investigation of fractures at Shelburne Point and Mount Philo, Vermont. Field studies advised in Summer and Fall 2012, Spring 2013.

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Ted Crook, University of Vermont, Department of Geology, BS, 2011. Groundwater investigation in Craftsbury, Vermont, using integrated geophysical technologies. Fall 2010–Spring 2011. This project was in collaboration with the Vermont Geological Survey.

Michael Ingram, University of Vermont, Department of Geology, BS, 2011. Interpretation of a Simple Bouguer Gravity Anomaly in Chittenden County, Vermont. Advising period: Fall 2010–Spring 2011. This project was in collaboration with the Vermont Geological Survey and Norwich University. Mike is currently an MS student in the Department of Geology at the University of Vermont.

Hagen-Peter, Graham, University of Vermont, Department of Geology, BS, 2010. "Large Scale Folding in the Tavan Har Basement Block, Southeastern Mongolia: Implications for Intracontinental Deformation". Advising period: Summer 2009–Spring 2010. Research presented at 2009 American Geophysical Union Fall Meeting, 2010 UVM Student Research

Conference and Spring 2010 Vermont Geological Society Meeting. Graham is currently a PhD student at the Institute for Crustal Studies, University of California, Santa Barbara.

Hefferon, Donald, University of Vermont, Department of Geology, BS, 2011. "Petrographic and Geochemical Analysis of Basement Rocks in the East Gobi Fault Zone, Mongolia." Advising period: Fall 2009–Spring 2010. Research presented at the 2010 Vermont Geological Society Meeting.

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Semple, Ian, Syracuse University, Department of Earth Sciences, BS, Spring 2008. "Early Mesozoic overprinting of Paleozoic protoliths during shear zone formation in the southeast Gobi, Mongolia". Advising period: Summer–Fall 2007. Supported by National Science Foundation Research Experience for Undergraduates supplement to grant EAR-0537165.

EXHIBIT B

Previous Four Years of Expert Testimony for Laura Webb, Ph.D.

Dr. Laura Webb has not testified as an expert at trial or by deposition during the previous four years.

Exhibit F

UNITED STATES DISTRICT COURT

DISTRICT OF NEW JERSEY

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IN RE JOHNSON & JOHNSON) MDL No.
TALCUM POWDER PRODUCTS) 16-2738 (FLW)(LHG)
MARKETING SALES PRACTICES,)
AND PRODUCTS LIABILITY)
LITIGATION)
)
THIS DOCUMENT RELATES TO)
ALL CASES)

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VIDEOTAPED DEPOSITION OF

LAURA WEBB, Ph.D.

BURLINGTON, VERMONT

FRIDAY, MARCH 29, 2019

9:28 A.M.

Reported by: Leslie A. Todd

Deposition of LAURA WEBB, Ph.D., held at the:

HOTEL VERMONT
41 Cherry Street
Burlington, Vermont 05401
(802) 651-0080

Pursuant to notice, before Leslie Anne Todd, Court Reporter and Notary Public, who officiated in administering the oath to the witness.

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CONTENTS

EXHIBITS

(Attached to transcript)

EXHIBITS (Continued)

(Attached to transcript)

EXHIBITS (Continued)

(Attached to transcript)

EXHIBITS (Continued)

(Attached to transcript)

P R O C E E D I N G S

THE VIDEOGRAPHER: We're now on the record. My name is David Lane, videographer for Golkow Litigation Services. Today's date is March 29th, 2019. Our time is 9:28 a.m.

This deposition is taking place in Burlington, Vermont, in the matter of Talcum Powder Litigation MDL.

Our deponent today is Laura Webb, Ph.D.

Counsel will be noted on the stenographic record.

Our court reporter today is Leslie Todd, who will now swear in the witness.

LAURA WEBB, Ph.D.,
and having been first duly sworn,
was examined and testified as follows:

THE VIDEOGRAPHER: You can begin.

MR. BURNS: You want appearances on the record or --

THE VIDEOGRAPHER: You can just begin.

MR. BURNS: Okay. Thank you.

Dr. Webb, before we get started -- and, Mr. Frost, this is directed to all -- we're going to lodge an objection on the record related to the

provision of new materials considered with respect to Dr. Webb's report.

By our count, we're looking at, between last night and this morning, a total of 14 new maps, approximately four new articles, and one new analysis of the Pooley Vermont samples, and -- that were not previously disclosed and which we have not had a chance to consider.

As a result, we're going to hold the deposition open until such further time as we've either reached an accommodation or the court has figured it out.

MR. FROST: Well, we obviously object to that. We also object to the characterization of what additional materials were provided on the -- the reliance list. We think it is significantly smaller than that.

We also object to the characterization of the Pooley data as, one, being new, and, two, being an analysis. I'm sure you will ask your questions about that today. We'll figure it out.

So, you know, your objection is noted, and so is ours.

MR. BURNS: All right.

DIRECT EXAMINATION

BY MR. BURNS:

Q Good morning, Dr. Webb. My name is Warren Burns. Again, we met right before the deposition. I represent the plaintiffs in the MDL. I'm from Dallas, Texas, and I will be questioning you today.

Dr. Webb, have you ever been deposed before?

A I have not.

Q Okay. A couple of simple rules for the road then. If you need a break, I'm more than willing to let you take one at any time. I only ask that if a question is pending, we get that out of the way, get the answer on the record, and then you're more than welcome to go. So just let us know if that's the case.

If at any time I am unclear, which certainly will happen probably multiple times over the course of this day, please let me know. I'm happy to clarify anything I say.

You are obviously an expert in many things, and the -- of which I am less familiar. So if I am unclear, please let me know, and we will try to get on through it.

What did you do to prepare for your deposition?
A Well, I met with counsel. I reviewed the reports, including my own. I reviewed the body of literature that I've been looking at.
Q Okay. Now, when did you meet with counsel?
A Multiple times.
Q Do you recall the dates?
A I -- well, yesterday and last Friday as well.
Q Were those meetings here in Burlington, Vermont?
A They were.
Q How many lawyers were present?
A Yesterday, two, and last Friday, three.
Q Do you recall any other meetings?
A Yes, there were prior meetings. I just don't remember the dates offhand.
Q Okay. Approximately how many prior meetings would you say?
A Two to three.
Q Okay. Now, during the course of your preparation for this deposition, were you shown any documents that refreshed your recollection?

A I was not shown any documents.
Q Now, Dr. Webb, I'm going to mark this as Plaintiffs' Demonstrative No. 1. It's nothing too serious, just a little roadmap for us as we go through the day today.
I intend to cover approximately four issues with you as we go through today, and we'll check them off as we get through them all.
The first is your response to the notice of deposition and subpoena that you received prior to the deposition.
The second involves your qualifications which underpin your testimony and report. I want to make sure I spell that right.
The third involves your preparation to render your opinions.
And the fourth is your report and opinions.
So I want to start with actually the subpoena. I'm going to hand you a few documents that we have premarked. First will be Exhibit 1, your report, or what I believe is your report.
(Webb Exhibit Nos. 1 through 3 were premarked for identification.)

BY MR. BURNS:
Q Exhibit 2 is the -- Exhibit 2 is the Notice of Oral and Videotaped Deposition of Laura Webb, Ph.D. and Duces Tecum.
And Exhibit 3 is Defendants' Response to Plaintiffs' Document Request contained in Notice of Oral and Videotaped Deposition of Laura Webb, Ph.D. and Duces Tecum.
There you go, Dr. Webb.
A (Peruses document.)
Q Ready, Dr. Webb?
A Yes.
Q Okay, great.
So let's start with Exhibit 2. This is the Notice of Oral and Videotaped Deposition of Laura Webb, Ph.D. and Duces Tecum. It's dated March 14th, 2019.
Do you recognize this document?
A I do not, no.
Q You don't recall seeing it before?
A (Witness shakes head.)
Q But you are appearing today to give testimony with respect to a report you previously issued; is that correct?
A That's correct.

Q And is that report reflected in Exhibit 1, Expert Report of Laura Webb, Ph.D., for General Causation Daubert Hearing?
A That appears to be the very report, yes.
Q Okay. Thank you.
Now, I would like you to look at Exhibit 3, Dr. Webb. That's Defendants' Response to Plaintiffs' Document Request contained in Notice of Oral and Videotaped Deposition of Laura Webb, Ph.D. and Duces Tecum.
Do you see that?
A Yes.
Q Okay. Are you familiar with this document?
A No, I'm not.
Q Okay. You don't recall seeing it before?
A No. I saw the notice of deposition, but I have not seen this.
Q Okay. Before coming to the deposition today, did you search your files for any relevant documents?
A Before -- sorry. What time frame are we talking about?
Q Well, let me ask a different question

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then.
Prior to your deposition today, were you informed that plaintiffs were seeking documents from you at the time of this deposition?
A I knew there -- I mean, I know there are documents requested in the notice of deposition, and counsel is responsible or, you know, responded to those. But that's --
Q I see. But did you -- were you personally informed that you needed to look for documents that were responsive to your requests from the plaintiffs prior to your deposition?
A I -- I provided everything that is in my reliance, but in terms of in the last few days being charged with searching my -- my records, no.
Q That's right. And we're really talking about that period between March 14th of this year, 2019, and the present.
So you don't recall being asked to search for additional documents during that period?
A I was asked to make sure that my reliance list was complete.
Q Okay. And do you recall when you were so instructed?

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A Oh, I believe we talked about that last Friday.
Q Now, again, staying with Exhibit No. 3, Dr. Webb, the first -- let's see -- the first 19 pages contains quite a bit of legal -- legal mumbo-jumbo that you're probably not too interested in that we may or may not fight about down the road with your lawyers.
But after that, the next page is titled Expert Report of Laura Webb, Ph.D. for General Causation Daubert Hearing, Supplemental List of Materials Reviewed.
Do you see that?
A Yes.
Q Okay. Is this a document you prepared?
A It is. I provided that list.
Q Okay. And you provided it to counsel?
A Yes.
Q Okay. Do you recall when you prepared this list?
A On Monday.
Q Okay. That would be Monday, March 15th?
A This past Monday, the 20 -- whatever. Yeah.
Q Maybe 16th.

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A Excuse me.
MS. O'DELL: The 26th -- 25th.
MR. BURNS: It's the 25th. Okay.
Oh, you're right. It's the 30th -- or 29th today. I apologize.
BY MR. BURNS:
Q Okay. So you prepared this document on Monday, March 25th, and the document contains 11 supplemental materials that you reviewed; is that right?
A Yes.
Q Okay. And the first five appear to be maps; is that right?
A Yes.
Q Okay.
A Or maps and reports in some cases, yes.
Q Okay. Can you tell me which ones also represent reports?
A Number 1, 3, and I believe number 5. Number 4, I'm not sure about.
Q And just so I understand, because there's a little bit of confusion on our side, when you listed these materials, and 1, 3 and 5 contain reports --
A Mm-hmm.

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Q -- is there any way we can figure that out from the -- from the -- from your citation? The citation appears to contain the title of the maps, but does that correspond to the articles as well?
A I mean, these are USGS report -- reports, open file reports. In some cases they're maps in a numbered series. So the general citations don't necessarily, yes, reveal that.
Q Okay. Now, the next item is "Zodac, P., 1940, A Talc Quarry Near Chester, Vermont."
Is that an article that you reviewed?
A Yes.
Q And item 7, Deposition of Ann G. Wylie. Is that a deposition transcript?
A Yes.
Q And next one is Expert Report of Ann G. Wylie. Did you have access to the entire report?
A I did.
Q And the supporting materials?
A Can you define "supporting materials"?
Q Yeah, the documents that would have been cited as the list of materials reviewed or relied on.
A I only read the expert report, so I

didn't -- there may have been some common materials cited, but I did not dig into those, so to speak.
Q Okay. The next one is Deposition of Mary Poulton, and that's a deposition transcript?
A Yes.
Q Next is Expert Report of Mary Poulton. Did you read the entire report?
A I -- I read good portions of it. I think there were some areas that I skimmed.
Q Did you have access to the whole report?
A I did, yes.
Q And did you review the materials reviewed or relied upon?
A No.
Q Next one is expert report of Darby Dyar. Did you have access to the full report?
A I did, yes.
Q And did you review that full report?
A I did. Again, portions -- some portions I read in more detail than others, but I did see the full report.
Q And did you review the materials reviewed or relied upon?
A No.

Q Okay. In Exhibit 3, Dr. Webb, if you go down, if you go to the end of the exhibit, there appear to be five maps or graphical representations that are part of these materials.
A Yes.
Q Okay. This may be a little difficult, but if we could stay with your supplemental list of materials reviewed. Can you tell me how these maps correspond, if at all, to those supplemental materials?
A Well, the -- the geologic map --
Q Now, we're looking there at the map that says "Google Earth Image, U.S. Geographical Survey"?
A Yes. So there are basically two map backdrops. There's the one that is much more complicated looking, and that is the Vermont State Bedrock map by Ratcliffe, et al., 2011.
Q Is that the first map in the material?
A Yes. And then the second one is the metamorphism tile from Doll, et al., 1961.
Q And if I can just pause you there. You said the first map was from Ratcliffe, and what was the date on that?
A 2011.

Q 2011. Okay. Now, that isn't listed in your supplement materials, is it?
A No. It's cited in my report.
Q Okay. And now, if you wouldn't mind proceeding to that second map.
A Yes.
Q Okay. And how does this correspond, if at all, to your supplemental materials?
A It does not.
Q Okay.
A I mean, I will make -- so the link between the supplemental materials and these maps are the -- the pushpins that mark the locations of certain mines or geologic bodies, for example. So when I first put this together, this is a Google Earth compilation. In terms of locating these bodies, in some cases on this Ratcliffe, et al., 2011 map, I also compared with maps, these more detailed quadrangle maps.
Q Okay. And when you refer to the more detailed quadrangle maps, you're referring to those that are listed in your supplemental materials?
A Yeah. So it was in providing this that I recalled I had looked at these many months ago

when I was determining locations, and that's why -- I haven't looked at them recently. This is why they were added as a supplement.
Q I see. Okay. So the second map we were looking in -- looking at, another Google Earth map, is this map cited in your report as well?
A Yes, it is. It's Doll, et al., 1961.
Q Now, let's turn to the third map. A lot going on in this one.
A Yes. This is a -- I zoomed in on the Chester dome area. So it's the same background map as the first one.
I'm sorry, I cut you off there.
Q No, that's fine.
Okay. So the third map is a zoomed-in version of the first map focusing on the Chester dome.
A That's correct.
Q Is that right?
A Yes.
Q And that is Ratcliffe, 2011?
A Yes.
Q Now, the fourth map, what are we looking at here?
A That's the zoomed-in version of the

Doll, 1961 map. So my -- yeah, generally I was trying to show the detail that you can't see in the first two.

Q Okay. And how do you -- is it D-A-L-L?
A I'm sorry?
Q Is Doll D-A-L-L?
A D-O-L-L.
Q D-O-L-L. Okay.
All right. And that leaves us with I believe one map. The fifth map, what is -- what are we looking at here?
A That's zoomed in further at the northern end of the Chester dome.
Q From the 2011?
A 2000 -- Ratcliffe, 2011, yes. Sorry, Ratcliffe, et al.
Q Okay. And this is the northern end of the Chester dome?
A Yes.
Q Okay. Let's start with -- I guess really the Ratcliffe map that's reflected in maps 1, 3, I think, and 5; is that right?
A Yes.
Q Okay. When did you prepare this map?
A Well, I began compiling this information

really when I was first retained by Shook Hardy & Bacon.
Q And was that in 2017?
A That's correct.
Q When you say you began compiling this information, what do you mean?
A I mean by determining the exact locations of -- of different geologic bodies on this backdrop of the -- the bedrock map of Vermont and the metamorphism tile.
Q Can you give us an example in this first map, the Ratcliffe, 2011 -- Ratcliffe, et al., 2011, of the type of specific information you were trying to show on this map?
A Yeah. So, again, for example, the Ludlow area mines, I was trying to determine the exact location of -- of those mines with regard to the geology.
Q Okay. And can you tell me where those are reflected on this map? I see, on your pushpins; is that right?
A Yes, yes.
Q Okay.
A So you see there's -- maybe two-thirds down the page almost, the Hammondsville quarry,

the northern end of the Chester dome. Then -- sorry, so again some things didn't show up well at this -- at this area. So Argonaut would be near the Rainbow and Frostbite mines, and then Hamm mine is further down.
Q And these pushpins carry over then to your zoomed versions?
A They do, yes.
Q Okay. And if you look at that map number 3, Argonaut mine, for example, there's pushpins somewhere sort of in the upper middle of the page; is that right?
A Yes.
Q What was your purpose in compiling this information and creating this map?
A Well, it's critical to understand the location of the mines with respect to the distribution of -- of geologic units, and in particular -- of particular interest is also the metamorphic grades of these rocks, which is why the Doll map is -- is used. Because the geology is actually very complex. There's -- I mean, three collisional orogenies that -- that give rise to the overall structure of -- of geologic units here.

And so there are pretty dramatic changes and grades of metamorphism over short distances, and I had to understand exactly where the mines were with regard to the metamorphic histories recorded by the rock units.
Q So how would you manipulate these maps to assist you in -- in coming to that understanding?
A I wouldn't manipulate them. I would just refer to them.
Q Okay. And perhaps that's the wrong term, but I assume you mean -- you're probably not looking at map number 1, but you're looking and trying to zoom in at times on maps 3 and 5 to get a better sense of the surrounding geology. Is that fair or --
A As a geologist, I'm always moving in and out of scales, from thinking about the whole state of Vermont scale to, again, the micron scale and samples. So, yes, moving in and out of zoom ranges is part and parcel.
Q Sure. Is it important then in addition to having sort of general maps or larger scale maps to have those much more finite and detailed maps of particular regions or areas?

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MR. FROST: Objection to form.
THE WITNESS: Yes, I found I was referring to those in detail because some bodies -- the level of detail shown in maps is a function of the scale of the map itself. So the 1:24,000 quadrangle maps show some finer scale details than the Ratcliffe map, but this was the best map available, the most up to date, and the best one for the -- the compilation of the data.
BY MR. BURNS:
Q And when you refer to the compilation of the data, do you mean plotting these multiple points, multiple mine sites on a single map?
A I mean, that's part of it again. It's, again, understanding the -- the system, the geologic system, the distribution of the rocks and the rock types and those geologic structures such as faults.
Q But if you were wanting to look at a particular -- a particular mine site -- for example, let's say the Argonaut mine or the Johnson mine -- you wouldn't want to start -- stop at map number 1 or even map number 3 or 5.
Would you want to get as much detail as possible and as much of the minute scale as

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possible when you were considering the geology of the area?
MR. FROST: Objection to form.
THE WITNESS: Yeah, well, I mean it depends on where the outstanding questions are, where you're driven to, in that sense.
BY MR. BURNS:
Q Okay. Well, if the question -- outstanding questions were, as they are in this case, say, proximity of a talc deposit to potential asbestos, amphibole or other materials, would you want that higher scale, more minute scale?
MR. FROST: Objection to form.
THE WITNESS: Again, I mean, you know, what I'm driven to search for is a product of what I'm -- I'm finding, and so -- and also what -- what actually exists.
BY MR. BURNS:
Q Well, and maybe I can be clearer, and I apologize if I'm not.
But as a scientist of your experience, and clearly you have published a lot and have significant length of time in this field, but if you were looking at, say, the Argonaut mine and

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ultimately wanted to opine on whether there was a potential for asbestos contamination in talc deposits in that mine, is it fair to say that you would want to drill down on the most finite or specific information, including maps on the Argonaut mine, before you made that opinion?
MR. FROST: Objection to form.
THE WITNESS: I mean, maps are part of it, but I was really looking at a much broader range of petrological information.
BY MR. BURNS:
Q So is the answer then that you would not want that fine level of detail?
MR. FROST: Objection to form.
THE WITNESS: I mean, the answer is it depends. I mean, we're kind of -- I think I would need more specific -- more specific questions in order to give you a more specific answer. Sorry.
BY MR. BURNS:
Q Well, for example, if there was a geologic map of the Argonaut mine available, would you want to see that?
A I guess, yeah, if there was good data and -- and context there. But I actually, you know, felt that I had the information I -- I

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needed based on the -- the resources that I looked at to have what I think is a very good understanding of the -- the petrology.
Q As a scientist, is it fair to say that more information is better than less information?
MR. FROST: Objection to form.
THE WITNESS: It depends. It depends on the quality of the information.
BY MR. BURNS:
Q Assuming that the quality is good, is it fair to make that assumption?
MR. FROST: Objection to form.
THE WITNESS: I guess, yeah, we -- yeah, information is good if there's -- if you're able to evaluate the -- the real data and the -- the methodology.
BY MR. BURNS:
Q Would it be important for you to actually review data or maps that were prepared by, for instance, a company actually operating the mine and having day-to-day experience with the extraction of minerals?
MR. FROST: Objection to form.
THE WITNESS: It depends what's -- you know, what's shown on those maps, I suppose, in

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terms of detail.
BY MR. BURNS:
Q I'm sorry. Did you --
A Yeah, I mean, I was going to say, again -- I mean, I really feel like I arrived at -- with -- at a place where I had the information I needed to basically meet -- meet my charge.
Because, again, I mean, what you see in the rocks is -- is not -- is not random. What we see is very specifically controlled by the bolt composition of the rocks, the pressure and temperature conditions under which they were metamorphosed, the fluids that were present, and -- so I really -- you know, a good deal of my effort was really trying to understand, again, the petrologic systems of -- of these rocks -- sorry, these mines -- in detail.
And so, you know, that information was -- was pretty clear from what I was able to review in the literature.
Q Well, and just to be clear here, you're speaking, I take it, of your opinion generally as to the propensity for some of these formations to result in asbestos contamination of talc; is that

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right?
A Yes.
MR. FROST: Objection to form.
BY MR. BURNS:
Q And that is a general opinion, not a specific opinion. Is that right?
MR. FROST: Objection.
THE WITNESS: That's pretty specific to these -- to these mines.
BY MR. BURNS:
Q Well, so, for instance, did you use maps 1, 3 and 5 to reach the opinion that there was no asbestos contamination in the talc that was mined in what I will refer to as the J&J mines? I think you may use that term in your report as well.
A Yeah. Well, this was a starting point.
Q Yeah. What do you mean by "a starting point"?
A In other words, I had to know where the mines were with respect to the geology of Vermont, with respect to the structure. That is, again, the result of multiple orogenic events that basically have folded and stretched these rock units that have a major impact, again, on the distribution of different metamorphic grades.

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And really it's about sort of the -- understanding the location of these is what helped me basically place these rocks in the context of the -- the evolution of this region.
So again, yes, this was a starting point for, again, sort of other literature searches and -- and determining the -- the types of other information I needed to compile.
Q But just so I'm clear at this early stage in the deposition as to your opinion, is it your opinion that there is no asbestos contamination in the J&J mines in Vermont?
A I see no --
MR. FROST: Objection to form.
THE WITNESS: I see no evidence to support the claim that there is asbestos in these mines.
BY MR. BURNS:
Q Among the materials that you've reviewed?
MR. FROST: Objection.
THE WITNESS: Well, I mean, my opinion is my opinion, which is based on the review of -- of multiple papers, maps, and reports, and so, you know, I didn't really adopt something that was

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stated in the literature. I -- I synthesized all that information to arrive at the opinions I presented in this report.
BY MR. BURNS:
Q No, and -- and we'll get back to that, and I didn't mean to insinuate otherwise, Doctor.
My point was really simply that your opinion is based on the materials you've listed in your report; is that right?
MR. FROST: Objection to form.
THE WITNESS: Yes, I've provided the reliance, and that is what I reviewed to arrive at my opinions, yes.
BY MR. BURNS:
Q Okay. And so if it's not listed in the materials that you relied on, then it's safe to assume that it is not something that you utilized to reach your opinion.
A I'm sorry, I couldn't hear --
Q Certainly.
A -- the last part of your question.
Q Yeah, no problem. I -- I'll restate it.
So if -- if a material is not listed in the materials upon which you relied in your report or the supplemental listing that your counsel

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provided last night, then it's safe to assume that you didn't rely on missing material to reach your opinions.
MR. FROST: Objection to form.
THE WITNESS: I'm not sure what you mean by relying on missing material. So --
BY MR. BURNS:
Q I'll switch it around. Is there anything besides those materials that you have listed in your report or in the supplemental list that we received last night on which you've relied in reaching your opinions?
A No. To the best of my knowledge, I've given you a complete list. Beyond, again, sort of the -- my general experience and educational background. Certainly that plays in.
Q Sure. So you began compiling the maps that are reflected in 1, 3 and 5 in Exhibit 3 as far back as 2017.
When -- when had you completed the compilation of information that's reflected in these maps 1, 3 and 5?
A Is this the first one?
I'm sorry, I'm just looking in detail at what's listed --

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Q No problem.
A -- on here and trying to think if there was anything added in the last year, but I would say this has -- this has existed for a year or so. The exact dates I don't remember.
Q And that's true of the zoomed-in portions as well?
A Again, this is from a Google Earth database, so you zoom in and zoom out in real time. So...
Q The compilation of material doesn't change.
A Right, that's correct.
Q Okay. Now, how did you establish the location of the pushpins on the maps?
A Oh, there were a variety of methods. In some cases locations were taken from the published literature. And that could come in a variety of ways, from actual GPS coordinates listed to descriptions.
So, for example, the Newfane mine is something that was basically a -- a description in a paper that then I conferred with the detailed quadrangle map to find the location, and then added the pushpin to this larger scale map.

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Others, I -- I confirmed by -- you know, I did some actual just general web searches. And so, for example, I think some of the -- the mine locations are based on having seen town meeting documents where they talked about wastewater permits and gave the actual road that the map was located on. So it was kind of a variety of ways.
Q I see. Were there any other sources that you used to create those pinpoints that you can recall?
A No. I mean, nothing noteworthy. Again, I mean, based on, you know, literature references and then trying to confirm the most precise location, like I said, with some of those permits that I saw.
Q Okay.
A So...
Q Now, throughout the day we're probably going to use the term "J&J mines" just for ease of reference in Vermont and elsewhere, and, you know, between China and Italy, I can easily distinguish those.
But what's your understanding of the J&J mines in Vermont that were used to source talc for Johnson & Johnson Baby Powder or Shower to Shower

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products?
MR. FROST: Well, I will just lodge a general objection to referring to the mines as "J&J mines." If it's fine with you, we can call it a standing objection so I don't have to object every time you say it.
MR. BURNS: That's fine, yeah.
And just to cover your concern, I'm not imputing in any way that they were owned by J&J or controlled.
MR. FROST: Okay.
MR. BURNS: That's a different issue.
BY MR. BURNS:
Q But really the source for baby powder used in -- or talc used in baby powder or shower -- Shower to Shower products. Sorry.
A Yes.
MS. O'DELL: Excuse me. You aren't saying they weren't -- aren't presently, but they could be known to produce.
MR. BURNS: Right. Right. Fair enough.
MR. FROST: Yep, that's fine. Just, you know, I'll lodge my general objection, but I --
MR. BURNS: Understood.
MR. FROST: -- for ease of reference,

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that's -- that's fine, pending my objection.
THE WITNESS: So my understanding is that the talc for talcum powders came from the Hammondsville, Argonaut and Hamm mines.
BY MR. BURNS:
Q And that's a complete list?
A As far as I --
Q That you understood --
A Yeah, for -- for Vermont, yes.
Q Now, you've included in your maps pushpins for several other mines in the area. Why did you do that?
A So, for example, the Frostbite mine, I refer to a study by Robinson -- I believe that's the name -- Robinson, et al., 2006. So they looked at the Frostbite mine.
The Grafton mine was in the Sanford, 1982, paper that I cite. Newfane as well.
So in some cases, you know, these are mines where there were detailed studies done that are relevant to what I was trying to accomplish in -- in terms of my understanding of the petrology.
Q Okay. Now, can you -- I'm looking at map number 1 and do not see the Argonaut mine

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referenced there. Is that a function of the scale?
A It is. And that's why part of the motivation for blowing up certain regions for detail, yeah, because those names would have overlapped in the first, yes.
Q I see. It is reflected in number 3.
A Yes.
Q The third map.
A Yes.
Q Now, how -- now, Ratcliffe, 2011, was cited in your original report. How, if at all, did these maps 1, 3 and 5 inform your opinions in your report?
A Well, again, it's the understanding of where the mines are located relevant to the geologic structure of the Chester dome, which relates directly to the grades of metamorphism of the rocks that are exposed on the surface around the dome.
And so, again, this was kind of a starting point in terms of location and units and structure that then feeds into the petrological analysis as a function of -- of metamorphic grade and history.

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Q Now, you've referenced the Chester dome, which appears kind of on the right-hand side of the -- of many of these maps.
What is the significance of the Chester dome?
A So, again, that's the main geologic structure. I mean, I think it shows up probably perhaps best on the Doll, et al., 1961, map here in terms of that elongate north-south blob.
But again, this is a dome that has a -- a sordid tectonic past. So the structure of the dome is, again, the result of the tectonic Acadian and the Alleghanian orogenies, and the -- the metamorphism that's recorded by these rocks around the dome is -- is -- basically it's dominated by the -- the Acadian orogeny, and this is the time at which the talc forms, during that tectonic event.
But subsequently, the rocks have been folded, so you have actually the deepest -- so the rocks in the core of the dome record the highest pressures and the highest temperatures, upper amphibolite up to granulite facies. So that has a direct control on the types of minerals that you would see, for example, in the Grafton and the

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Chester Carlton quarries.
And as you move, in this case, west or north, you move to lower grades of metamorphism. So, you know, the Hammondsville quarry is at a lower metamorphic grade relative to the Grafton or Chester Carlton quarries. The Argonaut and Newfane mines, they're again sort of pre- -- virtually similar to the Hammondsville.
So, again, you know, basically you've got this high temperature, higher pressure suite of rocks in the core of the dome and lower grade rocks mantling it.
Q And when you refer to lower grades of metamorphism, can you explain that?
A So, for example, in my report, I think it's Figure 6, I've got a diagram with pressure and temperature and different -- what geologists call metamorphic facies. These are regions and pressure temperature space where we expect rocks of similar bulk composition to show similar metamorphic assemblages as a function of those PT conditions.
And so while rocks, say, at Grafton were metamorphosed around 700 or 750 degrees C, Hammondsville, Argonaut -- sorry, centigrade --

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Hammondsville and the Argonaut, Hamm, Newfane, those were all at what we would say Greenschist facies conditions, which is roughly in the range of 550 to -- or -- well, to lower amphibolite, so 550 to 575 degrees C.

Q Okay. To shorthand that, and tell me if I'm right or wrong -- and I appreciate your answer -- compared to the Chester dome then, would you say that the rocks in the J&J mines were formed in lower temperatures and lower pressure?

A Yes, compared to the core of the Chester dome. So the center of that -- that elongate body, lower temperatures of metamorphism and -- and still relatively high pressures but lower pressures as well.

Q And I heard you use the term "TP." Is that temperature and pressure?

A PT, yeah.

Q Or PT, pressure and temperature.

A Yes, that's correct.

Q Okay. And it is PT, not TP?

A Maybe we say PT because TP sounds too much like toilet paper.

Q That's a fair point.

A But, you know, they're just

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abbreviations, shorthand, yeah.

Q Let's look at the Doll maps then, 2 and 4.

Well, actually, just briefly before I leave the Ratcliffe, 2011, these were produced last night. Have these -- has the -- have the -- let me strike that.

Do the inclusion of these maps in your supplemental materials provided last night indicate in any way that they have altered or changed the opinions in your report?

MR. FROST: Objection to form.

THE WITNESS: No. Again, these were created prior to the submission of my report, and in fact -- I mean, basically these -- there's a version of this map as a figure in my report that shows locations. So...

BY MR. BURNS:

Q And is that true of the Doll maps as well?

A Yeah, nothing has changed with respect to the Doll maps. I -- I refer to the Doll maps and the isograds, which again relates to the -- isograd means, on a map, a contour of equal grade of metamorphism. So I refer to -- I speak about

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that in the report, and I refer to Doll, et al., 1961, as well as Karabinos, 2010.

Q Now, the Doll maps here, tell me about your process for preparing these maps. How did you do it?

A Well, the Doll map preexisted me, my birth, by ten years, but -- excuse me -- basically by, you know, georeferencing the -- the map. So you can line up the boundary of the state of Vermont in the map with the boundary of the state of Vermont that you see in -- in Google Earth. And similar to the -- the bedrock map of Vermont. So I basically had different layers on the Google Earth map backdrop.

Q And what was your purpose for doing that with the Doll maps?

A Well, it's, again, the same thing in terms of seeing where the mines plot relative to grades of metamorphism that are presented in -- in this map.

I mean, I guess I would say that -- yeah, I mean, the purpose for choosing this map, again, because it showed the -- the whole state. The areas around the Chester dome have been refined slightly by Karabinos, et al., 2010.

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Q Now, when did you prepare this map or this overlay?

A As I said, I mean, I've had it for at least a year on my computer. So -- again, this was really the starting point of my -- my work on this issue.

Q Okay. Now, map 4 is a zoom of map number 2, correct, showing more clearly the Chester dome?

A Yes.

Q And it also shows the Argonaut, Hamm, and Hammondsville mines; is that right?

A Yes.

Q Okay. Among others.

A Yeah.

Q Okay. I'll drop that pen about 20 times today, so don't worry.

MR. BURNS: All right. How about we take a short break, and when we come back, we'll go through the other maps we got this morning.

MR. FROST: Okay.

THE VIDEOGRAPHER: Going off -- going off the record at 10:27.

(Recess.)

THE VIDEOGRAPHER: We're back on the

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record at 10:46 a.m.
BY MR. BURNS:
Q Welcome back, Dr. Webb.
I'd ask you to turn to your list of supplemental materials in Exhibit 3 again. It's about 20 pages deep.
A Okay.
Q All right. And before we get there, I was discussing with your counsel, and I understand that the maps we had been discussing, the five maps in Exhibit 3, those were contained in your files; is that right?
A Yeah. I guess I'm confused by the terminology --
Q That's fine.
A -- of -- so --
Q I understood that. I just want to make it clear and hopefully --
A Yeah.
Q -- save us some time. Those were maps that you had developed and created, and -- and presumably were saved on your computer; is that fair?
A Yes. Yes.
Q Okay. And you provided those after

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being requested to search your files by counsel?
A Yes. I think I understand the wording now, yeah.
Q All right. Going back to that supplemental list of materials reviewed, I want to go through in detail each of the first five entries. Starting with Ratcliffe, N.M., parentheses, 1996, Preliminary Bedrock Geologic Map of the Andover quadrangle, Windsor County, Vermont, U.S. Geological Survey open file report, parentheses, No. 96-32, scale 1:24,000.
Now, in addition to identifying what will end up being a series of maps, this entry also reflects an article; is that right?
A Yes, there was a written report that accompanied this.
Q Okay. And when did you review this report?
A Again, probably around a year ago or so. I -- again, I added these to -- to the reliance list in response to having generated the files that we were looking at, the -- the Google Earth images. So I recalled that I had a folder of maps that -- that were used when I was generating the pushpins, et cetera, on that -- on that. So it

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was a long time ago.
Q Now, did you -- did you read the actual report?
A I went through sections of it.
Q Okay. Do you recall when you did that?
A It -- again, it would have been at the time that I was putting together that Google Earth project. So...
Q Okay. Can you describe for the Court how, if at all, your review of this 1996 Ratcliffe article informed your opinions that you're offering in this case.
A Oh, like I said, basically the primary purpose -- or one of the primary purposes for looking at these was, again, to aid my ability to put those pushpins in in the map. But especially when there were -- I did look through the map indexes, the descriptions of units, and also if there were written reports, I looked through those to see if there were incidences of reported asbestos and, you know.
Q Do you recall anything specific about this 1996 article that informed your opinions?
A No.
Q Now, Dr. Webb, we are going to hand

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you -- and this may be a little bulky, I apologize -- Exhibits 4A, B and C.
MR. FROST: I was going to say is there a better way -- a better place to put these? Probably not.
MR. BURNS: We can put them back after she identifies them.
MR. FROST: Yeah, I was going to say -- I just want to make sure we have enough room to even, like, plop them down here. Move my stuff over.
(Webb Exhibit Nos. 4A, 4B and 4C were marked for identification.)
BY MR. BURNS:
Q All right. Thank you.
So Exhibits 4A, B and C, do those correspond to U.S. Geological Survey maps that are associated with the Ratcliffe '96 report?
A Yes, these are three plates as part of that report.
Q I see. And I think I understand based on your testimony, but can you tell us again how, if at all, you utilized these maps in reaching your opinions or in your work?
A Yeah, so again -- well, I would just say

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with respect to this map, I think I used -- this preliminary bedrock geologic map of the Andover quadrangle had the written report associated with it.
And then the number 2 on that reliance list is the digital bedrock map, so that actually had the colored map. So I think I -- I referred to the color version of the map because the details jump out better at you, and then -- and then looked at that in comparison to the -- the written report.
I mean, I'll be honest again, it's been a while since I've looked at these, so I kind of have to lay them down next to each other to figure out their spatial relationships in terms of, you know -- again, they would basically add up to what we see in that Ratcliffe, et al., bedrock map.
Q And that was maps 1, 3 and 5 of the supplemental materials?
A Yes.
Q Okay. Thank you.
And so did you obtain these maps at about the same time you obtained the Ratcliffe 1996 report?
A These are -- yes. I mean, these maps

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are part of -- if you go to the USGS site for that -- that report, you have access to the -- the written report and these plates all together.
Q I see. And so you obtained them at the same time?
A Yes.
Q Okay.
MR. BURNS: Why don't we hand her Exhibit No. 2, and then we'll take them all away. Or, sorry, Exhibit No. 5A and B, if I remember correctly.
(Webb Exhibit No. 5A and 5B were marked for identification.)
THE WITNESS: Okay.
BY MR. BURNS:
Q And, Dr. Webb, do these maps correspond to the second entry on your supplemental list of materials, Ratcliffe, N.M., 1996, digital bedrock geologic map of the Andover quadrangle, Vermont?
A Yes, they do.
Q And were these the maps you were just referencing and using the colored versions?
A Yes.
Q Okay. And when did you obtain these maps?

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A It would be about the same time basically.
Q And --
MR. FROST: Excuse me.
MR. BURNS: Bless you.
BY MR. BURNS:
Q Can you tell us whether these maps in any way impacted your opinions that you rendered in this case?
A Well -- again, I mean, using them for finding locations, so it was -- it was a starting point. I would say also in terms of the review of the -- the map unit descriptions and -- and the reports, the -- the lack of any report of -- of asbestos in -- in them, yes, was, in part, contributed to my opinion.
Q When -- when you said "the lack of any report of asbestos in them," were you referring to the elements on the map?
A I mean in total, in terms of seeing if -- if there's reference to -- yes, asbestos of any type in terms of the description of the units in the -- the map area, but also in terms of -- of the descriptions in -- in the written report.
Q Now, Dr. Webb, just so I'm not

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testifying for you, when you were referring to that area on the right-hand side of the map, what -- what is represented there?
Sorry, the right-hand side.
A Oh, sorry. This is the description of map units. So for each different colored map unit on here, there is a -- an age assignment, as it's understood, and a basic description of the rock type.
Q Okay. When you say "a basic description of the rock type," what do you mean?
A So right up at the top, it says, you know, for example, a map unit that's sort of purple, it says "DG," which stands for Devonian dikes, and the description is by type, "muscovite, granite." So short descriptions of both minerals and/or rock names that are standard.
Q Within that unit?
A Within that unit and within, yeah, the map area.
Q Within the map. Okay.
And you said there was an age identifier as well?
A Yes.
Q Okay. How are those age identifiers and

the rock or mineral identifiers developed? Who does that?

A It's the result of over a hundred years of work of geologists out in this region, so -- and USGS scientists, Vermont state geologists, academics who are -- and students who are involved in -- in mapping. So it's -- it's really a body of information that is refined over decades and decades of observation and analysis.

Q I see. Now, when you said you would look at the map units to -- and I'm not trying to put words in your mouth, but --

A Mm-hmm.

Q -- you said you would look to the map units to determine whether asbestos was identified. Is that right?

A Yeah. I mean, I was interested to see if it was mentioned anywhere, and then I would follow that -- that lead, but --

Q And what type or what designated map units would you be looking for to determine whether asbestos was identified?

A Well, it could be anything if it were there, but, I mean, of -- you know, of specific focus in this area of Vermont, of course, it's

the -- it's the ultramafic units.

Q Okay. And who are those?

A What kind of -- sorry, what kind of information do you mean or are looking for?

Q Ultramafic units, what do you mean by that term?

A Uh, right. So these are rocks that are basically derived from Earth's mantle. They're very rich in magnesium typically.

Q And what are the -- can you give us some examples of those asbestos-bearing rocks?

MR. FROST: Objection to form.

THE WITNESS: I can give you an example of the ultramafic rocks --

BY MR. BURNS:

Q Yes.

A -- that we were interested in about that question.

But -- so, for example, here it says, "Ordovician to late Proterozoic ultramafic rocks. Map units OZU and OZT, serpentinite and talc, and also talc schist."

Q And those are the types of ultramafic units that might contain asbestos?

MR. FROST: Objection to form.

THE WITNESS: They're the ultramafic units that are -- that are the protoliths for the -- the talc, ores in this case.

BY MR. BURNS:

Q How would they -- what's the association with asbestos in that context?

A Well, where asbestos is documented in Vermont, it's associated with some ultramafic rock units. More typically, I mean, the serpentinite and talc and talc schist here, these are basically the serpentinite formed during the tectonic orogeny, the talc during the Acadian orogeny.

The ultramafic rocks predated that. And where the ultramafic rocks are larger bodies that haven't been fully metamorphosed and recrystallized during these subsequent orogenic events, those are the rocks that -- that are reported to occasionally have those asbestos veins.

Q Okay. Now, when you use the term "asbestos," how would you define that term?

A I'm using that to refer to the six regulated minerals: So chrysotile, the asbestiform varieties of anthophyllite, actinolite, tremolite, grunerite and riebeckite.

Q And you did say tremolite, right?

A Yes.

Q Okay. Have you reached any opinions in your report with respect to whether chrysotile asbestos may be found in the J&J mines?

A I have not seen any indications of that. And again, the chrysotile that is reported in -- in Vermont, it formed during the tectonic orogeny, generally at relatively low grades of metamorphism in conjunction with like fracturing and fluid infiltration of the rocks.

So, if it were present in the J&J mines, as we're referring to them, those units underwent very extreme metamorphism, deformation and recrystallization during the Acadian orogeny.

So, again, I haven't seen any chrysotile reported in -- in the area in that general belt of ultramafic rocks that we're concerned with, and if it had been present, I wouldn't expect it to survive the -- the Acadian metamorphic event.

Q And when you -- just to be clear, when you say you haven't seen any indication of the chrysotile, I assume you're referring to -- you are referring to in the list of materials you've reported in your report; is that correct?

MR. FROST: Objection to form.
THE WITNESS: Yeah, I -- yeah. So, I mean, I -- in the documents reviewed. In the studies that I -- I looked at, no.
BY MR. BURNS:
Q All right. I think we can take these away.
A Thank you.
Q Now, I'm going to hand you a few documents under Exhibit 6.
(Webb Exhibit No. 6 was marked for identification.)
BY MR. BURNS:
Q Oh, just one document under Exhibit 6.
A Okay.
Q All right. Now, exhibit -- does Exhibit 6 correspond to the third entry in your supplemental list of materials, Ratcliffe, N.M., 2000, bedrock geologic map of the Cavendish quadrangle, Windsor County, Vermont?
A It does, yes.
Q Okay. And was there a report associated with this map?
A Not that I -- that I can recall, no.
Q And when did you obtain this map?

A Again, it would have been at the same time as the others, a year ago or so.
Q Okay. And to what purpose did you put the data reflected in this map?
A I'm sorry. Can you --
Q To what purpose did you put the data reflected in this map or this map itself? What did you do with it?
A Well, so this is -- I can recognize this right away. This is the northern end of the Chester dome, and so there are these small units, OZU -- I think it says OZU. So this is the Hammondsville mine, and it's basically at the northern end of this map.
And so, again, an important aspect of -- of this and the detailed position of that ultramafic body or the talc ores that are associated with it, is its position relative to this fault that outlines the -- the Chester dome.
Q Again, what is a fault?
A So a fault is a geologic structure across which there is displacement, and that displacement could range from -- I mean, we have microfaults, so it could be millimeters or centimeters of offset, and in some cases, you have

kilometers of -- of offset, like the San Andreas Fault, up to 300 kilometers there.
Here, there's a normal shear zone -- and I'll just explain that in a second -- a normal shear zone that bounds the -- the Chester dome, and it's a -- it's a high -- what we would call high strain, meaning if you started out with a -- something like a ball, it would be stretched into -- it could be a big, flat pancake or it could be a long cigar shape, or it depends on the nature of the deformation.
But basically the shear zone that outlines the Chester dome is the -- is part of what's responsible for the -- the major differences in the temperatures -- the higher temperatures that are recorded in the core of the dome relative to the units that flank it.
So, the Hammondsville unit would have been up here, and the core of the dome would have been up here, and after the faulting, basically they would be juxtaposed, and there would be a strong temperature and deformation gradient across that boundary.
Q And the last term you used "in gradient"?

A A temperature --
Q Or gradient?
A A temperature and -- temperature, pressure, and deformation gradient.
Q And when you say that, what do you mean?
A Well, I mean that over a short distance, you could walk across rocks that record very different temperature and pressure conditions of -- of metamorphism. In terms of the deformation gradient, that would be going from rocks that -- I mean, everything is deformed here, but that are less deformed into rocks, that are more intensely deformed and stretched, and then back out into a lower strain or less deformation.
Q I see. Now, are fissures commonly associated with fault lines?
A They can be, but it depends on, again, the pressure, temperature, conditions. So this is really -- I mean, this -- this fault zone, the temperature gradient across it, again, is kind of in the range from, say, 700 degree C to, say, 550 degrees C. And at those temperatures -- and it also depends on the details of the mineralogy, but in general that's hot enough where minerals are deforming by slip along the crystallographic

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planes. So we refer to that as ductile deformation.
So when you have deformation occurring under these higher temperature conditions, we tend to not have voids or fissures opening up. That's much more common in low temperature deformation environments where the rocks are deforming brittlely.
Q Okay. Do you know whether in fact there are fissures associated with this fault line around the Chester dome?
MR. FROST: Objection to form.
THE WITNESS: I have not seen really any descriptions of such features. Again -- and in my experience, I've actually worked in the shear zone some, so my observation of rocks in the shear zone is that it's more a continuum of ductile deformation. We haven't -- haven't seen, yeah, fractures opening up, filling with other minerals, et cetera.
BY MR. BURNS:
Q How would you identify a fracture or -- are fracture and fissure synonymous?
A Yeah, I mean, we don't really use the word "fissure" in geology so much, or at least not

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in my lexicon. But I think, you know, it's pretty similar. I mean, a fracture -- and, again, there's different types of fractures. There are fractures that the rocks just pull apart. There are fractures where there's some, like, little bit of slip along them, and actually there's a slip this way or slip this way, so there's mode 1, 2 and 3 of fractures, yeah.
Q Okay. So how would you identify, in the field, a fracture?
A Uh, well, it's -- usually you would see some -- a feature that crosscuts structural fabric in the rock. So these rocks out here are highly foliated, means that -- what that means is that basically during the deformation, there are planar elements that form. It could be defined by compositional banding. It could be defined by the preferred orientation of minerals are in the -- in the talc. Often that's the -- all the talc plates would be aligned in that foliation plane. And so there would be some truncation of that -- that fabric.
And it depends on when the fracture forms. If it formed very recently, it might just be an -- an open space, but if there are fluids

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that have moved through there, you might have crystallization of minerals.
Q And would that be what you were referring to a few minutes ago when you said -- referred to sort of minerals filling in the fracture?
MR. FROST: Objection to form.
THE WITNESS: Yeah, I mean -- yeah.
BY MR. BURNS:
Q As a general principle, when you have lower pressure and lower temperature, are the odds greater that you would have or could have an influx of water or liquids?
MR. FROST: Objection to form.
THE WITNESS: I mean, fluids will preferentially follow pathways, such as faults and fractures potentially, yeah. But, again, it depends on a lot of variables. Yeah.
BY MR. BURNS:
Q Okay. I think that moves number 3.
And just so I'm sure, was there anything in particular about Exhibit 6 there that impacted or informed your opinions?
A Well, again, it's the finding the location of the Hammondsville mine with regard to

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the details of the map.
Q Okay.
A And moving from there.
Q Thank you.
I'm now going to hand you Exhibit No. 7, and take No. 6.
(Webb Exhibit No. 7 was marked for identification.)
THE WITNESS: It would help if I had north up. (Peruses document.)
BY MR. BURNS:
Q Ready?
A Oh. Yes, sorry.
Q No, no problem.
A I can look at it all day.
Q So does -- Dr. Webb, does Exhibit No. 7 correspond to the fourth item on your supplemental list of materials, Ratcliffe, 2000, bedrock geologic map of the Chester quadrangle, Windsor County, Vermont?
A Yes.
Q And was there an associated report?
A I -- I don't recall offhand on this one.
Q With respect to this map, what was your -- when did you obtain it?

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A Again, it would have been at the same time.
Q And what was your purpose in obtaining it?
A Oh, again, just -- I mean, I was just sort of gathering the quadrangle maps for the region in general. This one, I do not believe we see any of the -- the different talc mines, but I think this is the southern -- sorry, the more southern half of the -- the Chester dome.
Q I see. So none of the J&J talc mines are represented on that map?
A No. I don't believe so, but I'd have to -- can I confer with my report map for a moment? Oh, this is not the colored one.
MR. FROST: Do you want a color -- I'm just showing her a color copy of the same page.
THE WITNESS: Yeah, so this is -- yes, this is the southern half of the Chester dome, and, no, none of the mines are located in the map area here.
BY MR. BURNS:
Q Okay. All right. Let's go to Exhibit No. 8.
And this is going to be 8A and B.

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(Webb Exhibit No. 8A and 8B were marked for identification.)
BY MR. BURNS:
Q Dr. Webb, do Exhibits 8A and B relate to the fifth entry on your supplemental list of materials, Ratcliffe and Armstrong, 2001, bedrock geologic map of the Saxtons River in Windham and Windsor Counties, Vermont?
A Yes.
Q Okay. And was there an associated report?
A Again, I don't remember specifically for -- for this one. I'd have to look at the website or my files.
Q And did you obtain these maps at roughly the same time as you obtained the preceding maps?
A Yes.
Q And were these maps again generally used to plot the location of the mines and -- and your inquiry into them?
A Yeah. Again, this -- this one is sort of the southwestern end of the -- the Chester dome. So I recognize this -- this lobe. None of the mines are in this specific map area.
Q Okay. All right. We can take that map

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from you.
MR. BURNS: Can we mark that as Exhibit 9.
MR. FROST: This is what, Zodac?
MR. BURNS: Yeah.
(Webb Exhibit No. 9 was marked for identification.)
BY MR. BURNS:
Q Dr. Webb, I've handed you Exhibit 9, which I believe corresponds to number 6 on your supplemental list, Zodac, P., 1940, a talc quarry near Chester, Vermont; is that correct?
A That's correct.
Q And it's published in Rocks & Minerals; is that right?
A Yes.
Q How, if at all, did this article inform your opinions?
A I looked at this after I had written my report, so it's -- it's not reflected in my report.
Q Did it change your opinions at all?
A No.
Q Have any impact?
A No.

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Q When did you first read this?
A Three weeks ago or so.
Q So early March?
A Yes. That's about right.
Q Okay. Did you -- did you find this article yourself or was it provided to you?
A I found it myself.
Q Okay. And why were you looking for it?
A Because I was reviewing the literature, again just in general preparation, and I came across this article cited in -- I believe it was Van Gosen, 2004, and I just thought I should -- I realized I hadn't seen it and I thought I should look.
Q And when you say you were reviewing the literature, the literature with respect to what?
A I mean just the things that are -- I've cited in my report or in the reliance list, but just -- there's so much information that I -- to keep nimble, just to kind of constantly trying to review and -- and remember.
Q When you were reviewing the literature, did you come across any studies or reports or articles that were contrary to your opinions expressed in your report?

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A No, not really. I mean, I -- I -- as I said, I spent some time looking in -- in detail -- well, a wide variety of literature, and for example, that included Van Gosen, et al., 2004, and -- and the 2006 articles that I cited in -- in my report. Some of those are summary articles, and so I really tried to go in and look at the primary literature, not to rely on -- on someone's summary.

But, you know, the Van Gosen, 2006, seemed relevant to follow up on the details of the citations, because in there -- in that report he published a map of asbestos localities in Vermont.

Q Now, you mentioned primary literature. What do you mean by that?

A I mean that I -- so, for example, the Van Gosen, 2006, map and digital supplements, what Van Gosen put on the map in terms of the localities where asbestos was presumably reported were not his first order observations. He had a citation list of the -- the people who made -- you know, presumably said that there was asbestos there. And -- and so I -- you know, I drilled down into that literature to try and see what information was in those articles, if I could

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verify basically the locations that he had shown on his map and understand their relationship to the -- the talc mines.

Q Were you able to verify those locations?

A Well, I was able to look at the literature that he cited, but in some cases, the -- the articles that he cited as reporting asbestos actually cited another article, and when I went to follow that trail, there was nothing in there in terms of a detailed locality. So I actually found that there were several dead ends.

Q Did that cause you to discount Van Gosen?

A Well, I mean, yeah, it gives me pause if -- because obviously there are big implications when you publish a map and say there's asbestos here, here, here and here, that if I couldn't verify the -- you know, the citations that were the basis of -- of that map, that -- that's, yeah, an issue, I think.

Q Now, when you say "big implications," what do you mean?

A Well, property values for people. I mean, obviously if -- I know that's been an issue up around Mount Belvidere, et cetera, but, you

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know, also the health implications for the people locally. So, I mean, you know, that -- it's the kind of thing that I think you want to be pretty certain about if you make that claim.

Q Do you know whether Van Gosen was -- felt pretty certain about it?

A I have no idea. I mean, I imagine, if he put that out there, but I don't know.

Q Were you ever provided details about the years in which the J&J mines were in operation?

MR. FROST: Objection to form.

THE WITNESS: I mean, I think I have a general sense from the sum of what I've read, which includes, you know, testimony in depositions, but -- I have an idea, but it -- you know, it wasn't -- the exact years weren't really critical for what I was doing.

BY MR. BURNS:

Q Were you ever informed that J&J sourced talc from the Johnson mine?

A No.

MR. FROST: Objection to form, belatedly.

THE WITNESS: I mean, not for cosmetic purposes.

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BY MR. BURNS:

Q Were you provided any information whatsoever on the Johnson mine?

MR. FROST: Objection to form.

THE WITNESS: No.

Well, I will say that -- actually correct one thing, in the sense that I saw a reference to it in the plaintiffs' reports and a citation for a Seymour thesis. So I did ask -- I wasn't able to access that thesis, so I asked counsel to provide that, if possible.

BY MR. BURNS:

Q And were you provided it?

A Yes.

Q Did you review it?

A I had a look at it. But, you know, the Johnson mine is so far up north and in a different portion of the belt that it -- it didn't really factor into my opinion.

And even though it makes reference I think to the Hammondsville mine, I -- I wasn't -- I don't know. A master's thesis isn't -- that makes peripheral reference isn't what I'm going to consider as like the key piece of information that my report would hinge on.

Q Is it your opinion then that the areas of the Johnson mine and the Hammondsville mine are geologically distinct then?
A Yes.
Q Now, in your supplemental materials that were provided last night, right before the maps in Exhibit 3, there is a spreadsheet for the Pooley report in Vermont.
A Yes.
Q And can you tell me what's reflected here?
A So when I reviewed the Pooley report, I created this table to basically write notes about his descriptions of the mineralogy, whether the mineral was a major or minor component of the rock or an accessory mineral, and -- and the different textures that were either described or present in the photomicrographs.
Q So these are your notes on the Pooley report?
A Yes.
MR. FROST: Objection to form.
THE WITNESS: I mean, it was a way -- a way to sort of organize the -- the data, yeah.
BY MR. BURNS:

Q When did you make these notes?
A Oh, I'd say in January probably.
Q And that's 2019?
A Yes. Yeah.
Q Okay.
A Well, actually, I'll take that back. The Pooley report would have been sometime earlier for Vermont, but the -- the Italian -- there was a table for the Italian.
Q So you have another table for the Italian mine?
A It's the same form, yeah. Basically, yeah.
MR. BURNS: Jack, if you can find that.
MR. FROST: We'll take a look, and we'll figure out if it's in there or not.
THE WITNESS: Yeah, it would have been a second tab in the Excel file, I think.
MR. FROST: Yeah, we'll take a look. We'll get back to you after a break.
MR. BURNS: Sure.
BY MR. BURNS:
Q What use did you put to this table? How did you use it, if at all?
A Well, sometimes -- I mean, I -- as I'm

reading something, I make notes like this to just sort of help process the -- the information. So -- and it gave me a quick way to refer -- if I wanted to refer back to his report to check on something, this gave me sort of a quick way to navigate to, say, a particular sample, et cetera.
Q Did you try to be as thorough as possible in -- in recording the information from his report?
MR. FROST: Objection to form.
THE WITNESS: Yeah, I mean I -- I worked -- as I read the results or the descriptions of a particular sample, I -- I made these notes. So -- I certainly wouldn't be motivated to have it be inaccurate, but --
BY MR. BURNS:
Q Okay. And your recollection of the Italian spreadsheet or form, can you talk about that a little bit. Were you doing the same thing?
A It's the same thing in terms of headings across the top would relate to the samples that he had petrographic descriptions for. And then the -- sorry, and then in the first column would be the -- the list of the different minerals that were mentioned. And so it would be

the same format with the major, minor, accessory, and any notes related to the -- the textures observed.
Q Now, you prepared this before your original report?
A Yeah, the -- the Pooley report from Vermont is actually the -- the first document I ever saw, and it was prior to when I was retained. So this -- it would -- yeah, the first time I saw this report would be back in probably May of 2017. I think I made the table during that summer, but...
Q Okay. And with respect to the Italian report?
A Again, I think -- I think I saw that -- that prior to this litigation, but that table I created -- I rereviewed the report, I think, as I said, in January and created that table at that time.
Q And that's the Italian table, just to be clear?
A Yes.
Q So the Pooley report for Vermont, you reviewed sometime summer of 2017?
A Yes.

Q And created this table?
A (The witness nods.)
Q Now, preceding that, there are graphical representations that look pretty similar to some of the things in your report.
Can you tell us what the two preceding pages encompass?
A Yeah, so there's -- yeah. It's basically this was an early version of the -- the table that shows up in -- in my report. There's some places where I just had some other notes that I -- that I jotted down.
So -- yeah, it's a bigger spreadsheet, so it shows this -- it would be continuous in my Excel file, but it shows up on multiple pages here.
Q I see. So --
A So page 1 would be the first column that would line up with page 2, and --
Q Okay. So the first column would be --
A The mineral name.
Q -- mineral and talc, and then the second column would be formula. Correct?
A Correct, yes.
Q Okay. And what is the next page then?

A That would be the final column. So just for quick reference, if I had -- I often had the mineral table up when I was reading stuff to -- just to be able to refer to quickly, and also so then I pasted in a picture -- again, this is I think the same image that's ultimately produced in -- in my report about the -- the amphibole structure.
There is a column on, yeah, the Fe sites, so the M2, M4, M -- or whatever number, all refer to specific lattice sites, and you can see them in the image that adjoins that.
Q Mm-hmm.
A But the question being where -- where does iron live in the mineral lattice in -- in different amphiboles.
Q I see.
A "Live" not being a great word for that, but where does it reside typically.
Q Flipping past the maps, there are a couple of retention letters, one by Tucker Ellis, one by Shook Hardy & Bacon; is that right?
A Yes.
Q And you were retained by Tucker Ellis in October of 2018?

A Yes.
Q And was that for purposes of the MDL?
A That was prior to being brought into this.
Q Prior to being brought into this case?
A Yes.
Q I see. Were you retained generally or was it for a specific litigation?
A I was retained generally. My understanding is there was sort of a -- a reorganization, and I have no idea how this works, but -- of who deals with --
MR. FROST: I was going to say, I'd instruct you not to talk about what any of the lawyers --
THE WITNESS: Oh, okay.
MR. FROST: -- have told you about, you know, but --
THE WITNESS: I was asked to sign a new retainer in October because of something that, I don't know, was reorganized in the structure of things, and so I signed a new retainer with Tucker & Ellis.
BY MR. BURNS:
Q So Tucker Ellis replaces the Shook Hardy

retainer.
A It does, yes.
Q And the Shook Hardy retainer, which was signed back in June of 2017, was that for a particular piece of litigation or generally?
A No, that was just general consulting.
Q Okay. And your fee there was $250 an hour; is that right?
A Yes.
Q And with respect to the Tucker Ellis retention, it increased to $458 an hour; is that right?
A Yes.
Q And why is that?
A Well, the -- for one, I had a -- I think a better understanding of -- there was more expertise on this topic at the time of the re-signing, plus it was looking forward to -- I mean, looking ahead to work like this. And so in my, you know, prior work, I was -- well, there's a different level of intensity and commitment and inconvenience now, and so the price went up.
Q I'm sure that everyone on both sides of this table can relate.
Now, following that are I think invoices

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that you sent to Tucker Ellis; is that correct? Three of them?
A Sorry, following that, is that -- yes.
Q And the details of those invoices are redacted; is that right?
A Apparent- -- yes.
Q Okay. Do you recall whether the redacted portions -- I'm not going to ask you what they say -- but do you recall whether they reflected communications with your counsel?
A There was some of that in there.
Q Okay. Was there other noncommunication-related detail around your work?
MR. FROST: Objection to form.
THE WITNESS: Noncommunication-related, you said?
BY MR. BURNS:
Q Yes.
A Yes.
MR. BURNS: And we would ask, Mr. Frost, that y'all review those redactions to determine whether there are any pieces that can be produced.
MR. FROST: I'll take it under advisement.
BY MR. BURNS:

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Q Okay. Well, I'll put this back up because we've hit something of a milestone, Dr. Webb, and I think we've largely exhausted most of the portions of the subpoena. So we can check that off, and we'll go to your qualifications.
MR. BURNS: Given where we're at, it might make sense to take a break.
MR. FROST: I was going to say we can take a break now. I don't know what your plan is for lunch. I don't know how long the qualifications is going to take. You know, I would say if it's going to take a half hour, you might want to do that, and then break for lunch. If you think it's going take a little longer, we can, you know --
MR. BURNS: Yeah, it might.
MR. FROST: -- take a really short break now, and then maybe break for lunch at 1:00.
MR. BURNS: Yeah, that's fine. Why don't we take --
MR. FROST: Maybe you may want to take a short break, and then --
MR. BURNS: Sure.
MR. FROST: -- we'll make it through this area.

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THE VIDEOGRAPHER: Going off the record at 11:41 a.m.
(Recess.)
THE VIDEOGRAPHER: We are back on the record at 11:58 a.m.
BY MR. BURNS:
Q Welcome back, Dr. Webb.
So, Dr. Webb, we're going to start going through your qualifications, your background and experience. It's the next step on our journey.
In the supplemental materials you -- your counsel provided last night, there is a CV or resume on -- let's see -- it's right past the supplemental list.
A Okay.
Q Now, is this your current CV?
A I believe so. I haven't checked what's in here, but I did send them an -- an updated CV that was included.
Q Okay. Now, I take it you graduated high school in 1990?
A 1989.
Q Oh, '89. All right. Well, we're only a year apart. But you got your Bachelor of Science in geology at UCLA; is that right?

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A Yes.
Q And from there you went to Stanford?
A Correct.
Q And in 1999, you received your Ph.D. doctoral degree in geological and environmental sciences; is that right?
A That's correct.
Q Now, did you have a specific area of emphasis in your doctoral work?
A Well, there were two main projects thematically, but they basically involved development of the same areas of expertise, and that is petrology and, more specifically, metamorphic petrology being a focus of my work: The study of rock structures or rock deformation and its relationship to metamorphism; and then also the radio- -- excuse me -- the radiometric dating of minerals to then understand the -- the timing of metamorphism and deformation.
Q All right. Can you describe what radiometric dating of minerals involves.
A Yeah. So for many elements, there are different isotopes, which differ in the number of neutrons in the atom. Some of these are radioactive, so in particular, my -- the technique

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we do in my laboratory is -- is fundamentally based on the decay of potassium 40 -- that's the isotope number -- to argon 40.

And so -- but we do a variation on that that I can describe if you want. But basically, we analyze the -- the isotope ratios of the radioactive parent and the daughter product to determine an absolute age.

Q And by "absolute age," what do you mean?

A That would be, say, to say -- calculate an age of like 544 million years rather than generally referring back to the Cambrian or something like that. So...

Q I see. So in layman's terms, if I could hand you a rock, theoretically you could take it back to your laboratory and date it through that process?

A Yeah, as long as -- in my case, as long as there are potassium-bearing minerals.

Q I see. And do those attend certain types of rocks?

A Yes. It's all a function of the bulk composition of -- of the rock. But, yeah, certain -- certain rocks you can -- are pretty much guaranteed you can find these potassium-

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bearing minerals in, yeah.

Q I see. Are there certain rocks that are on the other end of that equation where you can assume that you don't have those potassium-bearing mineral -- minerals?

A Yes.

Q What types of rocks are those? Do you have some examples?

A Well, so rocks that don't have significant potassium in them, like the ultramafic rocks, for example, or a quartzite or a marble or -- I mean, sometimes we can do a whole rock analysis. But, yeah, I mean, the -- the -- generally the mineral -- mineralogy is a function of the bulk composition among the other variables of metamorphism.

Q I see. So with respect to talc then, it's fair to assume that you're not ordinarily using rocks containing talc mineral -- minerals in your dating process. Is that fair?

A Well, there -- there may be the possibility of that, but -- again, it just depends on the bulk composition of the -- of the rock and the -- and the history.

But, you know, pure -- like these talc

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ores of pure talc and magnesites, they would not be the ideal targets for that.

Q I see. During your doctoral work at Stanford, did you perform any studies or -- or let me leave it there.

Did you perform any studies that involved talc as a mineral?

A There was talc present in -- in some rocks, yes.

Q But did you -- were you focused on the talc itself or focused on some other aspect of the rock?

A Well, I was focused on -- I mean, again, the same basic principles, understanding the mineralogy and the textures in different rocks, the relationship of that as deformation, and then, again, based on the -- the thematic problems I was working on, you know, finding other targets for -- for dating. So it wasn't basically focused on -- on talc itself, but...

Q Did you do any work that was specifically focused on asbestos?

A No.

Q Now, your doctoral dissertation was in exhumation of high and ultra high pressure rocks

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in the Qinling-Dabie --

A Qinling, yeah.

Q -- Qinling-Dabie -- is it Dabie or --

A Dobby (phonetic).

Q Dobby (phonetic).

-- Qinling-Dabie orogen?

A Yes.

Q Eastern China and --

A The Yagan-Onch Hayrhan metamorphic core complex.

Q All right. And we are going to have to spell this --

MR. FROST: I was going to say, we'll get you a list.

BY MR. BURNS:

Q Can you describe generally what this dissertation was about?

A Yeah. So those -- those are actually two projects in that -- that title. So the "Exhumation of high and ultra high pressure rocks in the Qinling-Dabie Orogen," so there we had basically a continental collision that occurred at the end of the Permian, early Triassic, and you had the leading edge of the continental margin went down a subduction zone, down to mantle

depths, like 90, 100 or more kilometers depth, and somehow those rocks came back to the surface. And so in some of those rocks, little bits of carbon turned into microdiamonds and quartz turned into coesite, a high-pressure polymorph, as a function of having reached those high pressures, and somehow they were brought back to the surface.

And so when I was in my Ph.D., this was early after the first reports of these ultra high pressure rocks at the surface, so we went to the Qinling-Dabie Orogen, which was one of the largest orogenic belts where this was recorded, to try and again document the different metamorphic assemblages, their relationship to different fabrics that would form during deformation, during exhumation, and also to try and date the timing of when did the rocks first reach those depths and how, and how fast did they come back to the surface.

So it's really an integrative piece of metamorphic petrology, structural geology, and again the radiometric dating.

Q Did you figure out how they came back up?

A Yeah.

Q How was it?

A Plates reorganize and the subduction zone got reactivated as a normal fault system. And so basically, because South China started moving, relative to today's geographic coordinates started moving south again, it basically pulled that continental margin out of the subduction zone.

Q Okay. Now, when you mentioned going to the Qinling-Dabie Orogen, did you physically visit the site?

A Yes.

Q And what did you do while you were on site?

A We found outcrops where we observed the metamorphic -- again, metamorphic rock types, and really there, in particular, documenting the structures and taking sample -- oriented samples to then bring back and make thin sections, and look at the petrography and also choose select samples for dating.

Q So once you brought those samples back and did the thin sections, you were able to look at the structure of the -- of the rock. Is that fair?

A Yeah. Well, that -- in the thin section, look at the microstructure and integrate that back into the outcrop and regional scale.

Q And you were also able to date the rocks; is that right?

A Yes.

Q Okay. Now, after you received your Ph.D., it looks like you went to the University of Geneva in Switzerland; is that right?

A That's correct, yes.

Q And what did you do there?

A I -- well, I worked in the -- the argon -- so this is the same type of lab that I have here at UVM, but the argon laboratory, and -- pardon me.

Q That's okay.

A There I was working with igneous petrologists, and so we were dating some samples from the -- the Andes.

Q And from there you went to Syracuse University; is that right?

A That's correct.

Q And you, it looks like, worked in both the noble gas isotropic research as a research laboratory manager and as an assistant professor?

A Yes.

Q Okay. And what was the focus of your work while you were at Syracuse?

A Well, when I first arrived, the lab was an empty room, so I actually helped build and commission the laboratory. And then we turned our attention to different projects. A big focus of my research there was on Papua, New Guinea.

Q And the rocks in Papua -- Papua, New Guinea?

A Yes.

Q I see. What exactly is a noble gas isotopic research?

A So argon, neon, helium, they're all noble gases. They have filled outer electron shells, so they don't bond with other elements.

Q I see. Just like kings, they don't play well with others, right?

A Yeah, they don't need anybody else.

Q And from Syracuse, you went to the University of Vermont; is that right?

A Yes.

Q Okay. And that was in 2009?

A I started here in the fall of 2008.

Q Okay. And you are still at the

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University of Vermont; is that right?
A That's correct.
Q And are you an associate professor today?
A I am, yes.
Q Has there been any particular focus to your work here at -- in Vermont?
A Again, general themes of integrating metamorphic petrology and structural geology and -- and age dating. I've worked in Papua, New Guinea, I've worked in Mongolia, and I've been working a lot in -- in Vermont.
Q When did your work in Vermont begin?
A Pretty much upon my arrival.
Q Mm-hmm. And what has been your focus there? Is there a particular area, geographic or otherwise?
A It varies. I mean, I guess the Chester dome area is the farthest south, and then I've worked in the Tillotson Peak complex, so that's a -- in the northern part. I mean, generally kind of in the Green Mountains generally, but also in the Lake Champlain basin.
Q And what have you been trying to do in the Green Mountains? Is there an overarching

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theme to your work there?
A Well, it -- it depends. Again, there's a very complex geologic and tectonic history. You know, we have these very beautiful, detailed geologic maps, but there's a lot of room for refinement in some of the ages of events, and particularly looking at the -- the reactivation of structures that formed earlier in the history. So you might have a fault that's formed during the tectonic orogeny that a hundred million laters -- million years later, another continental block comes and then slams into North America, and that fault moves again.
But, again, being able to look at the microstructure and choose targets for dating to resolve those different events.
Q Now, you mentioned you had worked out at the Chester dome. What have you -- what has been your experience out there?
A I have a master's student currently working on the -- the eastern margin of the -- the dome, and also the southern portions, which technically some people call the Athens dome. But we're basically trying to refine the timing of the formation of that shear zone, the one I described

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that resulted in vertical thinning and the juxtaposition of the rocks at different metamorphic grades.
Q Are there differences between the eastern margin and the western margin?
A We've looked at some over there. Our -- the -- I mean, this is the beginning of that sort of investigation. But the reason I mentioned the eastern margin specifically is because there, there happen to be roads that cross good exposures of rock types where you can do a sampling transect from the core through the attenuated mantle unit. So it's more about the opportunity -- the sampling opportunities there.
Q Roads have been cut through that?
A Right. You might -- well, it's not very green here now, but -- the -- the foliage poses some challenges at times, yeah.
Q And what have you done on the southern -- on the Athens dome region or that southern region?
A Again, just in particular, some very good outcrops there that allow for some more detailed study.
Q Have you reached any conclusions or

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dating?
A No, this is -- we're in -- in progress right now.
Q I see. And we've used the term "dome" a lot. Can you describe for the record what a dome is?
A Yeah. So, again, it relates to folding of the rocks. So, you know, there are layers of -- of rocks, say, and tectonic forces cause folding. And so the Chester dome is -- well, again, there's multiple events that have done this. There was first sort of intense north-south stretching, and then the Acadian orogeny resulted in this sort of east-west folding. So that's partly how -- why we have this long north-south structure. So...
Q Now, on the second page of your CV, there's an area for Technical Expertise.
A Mm-hmm.
Q The first entry there refers to Nu Noblesse, MAP 216 and Micromass 5400 noble gas mass spectrometers for argon 40 and argon 39 thermochronology.
And again, are those tests or processes to date rock?

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A Yes.
Q And I take it those are specific tests you would -- and those are the processes you enlisted, right?
A I'm sorry?
Q Are those specific testing devices or testing processes, rather, that you would use?
A Yeah. These are magnetic sector, mass spectrometers, so that's -- yeah, how we're doing the isotopic analyses.
Q Okay. Next one is Balzers Prisma QME 200, and that's another mass spectrometer?
A Yes, that's a quadrupole mass spectrometer, so -- as opposed to taking up one of these large tables, it's more of a football-shaped item, but that is used, yes, specifically for that uranium-thorium-helium dating technique.
Q Okay. Next is design, construction and maintenance of ultra-high vacuum extraction lines.
A Yes.
Q What does that involve?
A That's the front end to my mass spectrometer. So there's actually argon in the air we're breathing right now, and so we have to -- we've built this stainless steel line that

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is -- inside that envelope, stainless steel envelope, pressures are about 13 orders of magnitude lower than the pressure we're enjoying today, because we have to get all that background argon out of the system in order to be able to measure precisely what comes out of our samples.
Q Then you list management of radioactive materials and isotopic inventories. Is that primarily argon?
A Yes. In order to get to this argon 40, 39, from that potassium-argon technique, we actually have to irradiate our samples with fast neutrons and a reactor.
Q I see. Is that done under controlled conditions of --
A Yeah, I mean, I'm not involved with the -- the nuclear reactor. That's a service that's provided to us, yeah.
Q Yep. Other analytical experience, you have electron microprobe analyses. What does that involve?
A So basically that's a scanning electron microscope that has WDS protectors that are higher -- generally higher precision detectors than the EDS or EDAX.

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Q And what are those used for?
A For detailed elemental analyses. So you might want to look at the chemical zoning in minerals. You might want to measure absolute concentrations of different elements, because we can then use that information to do thermobarometry to determine the -- again, the pressures and temperatures of -- of the formation of a mineral that that records.
Q Okay. The next one is secondary ionization mass spectrometry.
A Yes.
Q What does that involve?
A So that's a different type of mass spectrometer where you basically ablate a sample with an ion beam. That ion beam basically drills a hole and ionizes material.
So this is in situ work. So you might be making a 10 micron spot within a zircon grain, and then -- then those ionized atoms -- or they're ions at that point -- are analyzed, say, for uranium-lead isotopes.
So it can be used for, again, radiometric dating or I've also used it for a technique related to the -- titanium concentration

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in quartz. Again, a thermometer or barometer-type technique.
Q Have you ever used a scanning electron microscope to identify particular minerals?
A Yes.
Q What type of minerals?
A I mean, it depends on what's -- what's on the menu in your rock, but -- well, the amphophiles, garnet, muscovite, biotite. Yeah, I mean --
Q Okay. Next one, laser ablation inductively coupled mass spectrometry.
A Yes.
Q That's a mouthful.
A Yeah. So that one you -- again, it's a mass spectrometer, a magnetic sector mass spectrometer, but in this case the -- the liberation of atoms from the sample is done generally with an excimer laser, so that's in the UV range of the spectrum. So very short wavelength, high energy laser that, again, can drill a spot into -- a 10, 15, 20 micron spot into a mineral grain so you can actually date different zones in minerals. So that -- that's used for uranium-lead dating of zircon, for example.

Q And the last one, just to make sure we get them all, cathodoluminescence imaging?
A Yeah. So that's again using a scanning electron microscope, but a cathodoluminescence detector basically -- well, you can see different things. Again, that was part what I used for the titanium and quartz. So if you were looking at quartz with that technique, zones in the mineral that had higher titanium concentrations would show up brighter, for example. So you could identify zoning, and then identify -- use those maps of zones to target where you would drill into either with the ion beam or subsequent analyses.
THE REPORTER: Subsequent what?
THE WITNESS: Analyses, yeah.
BY MR. BURNS:
Q And the next entry in your CV is consulting experience. And you list from 2007 to present the work you've done for law firms for J&J; is that right?
A Yes.
MR. FROST: Objection to form. It's 2017.
MR. BURNS: Yeah, 2000 -- I said '7.
BY MR. BURNS:

Q 2017 to the present, right?
A Yes.
Q Okay. I almost snuck that one past your counsel, but I failed.
Have you done any other consulting experience for -- in litigation?
A No.
Q Okay. Have you done any other consulting experience for industry?
A No. Not consulting, no.
Q Okay. Do you consider yourself a mineralogist?
A I certainly use mineralogy, so, I mean, there's kind of a spectrum of expertise out there. So I would describe myself as a -- as a petrologist rather than a mineralogist, but I certainly do have some expertise in mineralogy.
Q What's -- what's the difference between those two?
A Well, most typically, if someone describes themselves as a mineralogist, then -- for example, the faculty member in our department, he is an expert in the structures of apatite crystals, and so is looking to determine, yeah, the mineral structure where different elements

are -- are sited, how they're bonded.
Q Mm-hmm. And how would you contrast that with a petrologist?
A I'm generally looking at rock systems. So rather than -- I mean, I certainly use mineralogy in order to determine what minerals I'm looking at, but then what I'm interested in, after the mineral ID, is understanding the relationships between different minerals. Because you might have different assemblages in a rock that, again, record different parts of that rock's history.
So, yeah, using mineralogy and mineral structures, and again, I also get into the structural geology side, but it's -- it's really trying to understand the -- the formation and the evolution of rocks, but what they record in terms of geologic and tectonic processes.
Q I hand you what we'll mark as Exhibit 10, Dr. Webb.
(Webb Exhibit No. 10 was marked for identification.)
MR. FROST: Thank you.
BY MR. BURNS:
Q Now, is this your bio on the University of Vermont system?

A It looks like it, yes.
Q Okay. And similar to what we've been discussing, on the back page it lists your areas of expertise and a researcher in tectonics and thermochronology, correct?
A Yes.
Q All right. And under "Teaching Research," there are a couple of things I wanted to understand a little more fully.
First, in the first sentence it says: "I am a field-based geologist."
What is a field-based geologist?
A Well, in that -- in many cases I'm actually out in the field making structural measurements, collecting oriented samples. That kind of depends on the nature of -- of the question that I'm trying to address, but it means that I have a skill set that allows me to do that as needed.
Q And what is that skill set?
A Well, the ability to recognize different rock types in the field, the ability to recognize and document structures, to make the appropriate measurements. For example, the orientation of foliations, or we also have lineations. Minerals

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can be elongated or pebbles can be stretched, for example. All this relates again to the structural evolution of -- of the rocks.
Q All right. Now, in the next paragraph it says you teach courses in geochronology, petrology, microstructural analysis and tectonics.
And then, "In the classroom and in practice, my students and I integrate analytical data with observations at microscopic to continental scales to try and understand how rocks and regions evolve in space and time, and the tectonic processes that shape them."
Did I read that correctly?
A Yes.
Q Okay. Now, when you refer to "integrating analytical data with observations," what -- what are you referring to there?
A Well, it -- it depends on, again, the -- the specific study at hand, but again, I -- in my work, let's say if I want to date a mineral and we -- the mass spectrometer spews out some information that we calculate an age from, that age is only as good as my ability to interpret what it means.
So that means that I have to understand

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the context of the mineral I dated in the rock. I have to understand the context of that rock in an outcrop. I need to understand the context of that outcrop in the -- sort of the map scale.
And so we're integrating the -- the isotopic data. We're integrating the observations of the minerals and the mineral assemblages, and their relationship to deformation, coupled with field measurements.
Again, it depends on the study what -- what all is at play, but also, you know, integrating this with the existing literature out there, which generally drives the nature of the question.
Q Right. And I'm going to assume your field-based skill set assists in that process by allowing you to observe the minerals, rocks in question in the area in which they occur, and juxtaposed against other formations or other rocks or minerals, right?
MR. FROST: Objection to form.
THE WITNESS: Yeah, in part. But again -- yeah, I'm sorry, I think I lost the thread there. It was a long one.
BY MR. BURNS:

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Q No, fair enough. And really I'm just saying that you described a pretty unique, I think, field-based skill set, one that maybe I wish I had. I would love to be able to look at a hillside and -- and take an instant view of the rocks there and how they fit into the structure.
But what I was getting at is those field-based skills allow you to put the rock or mineral you're examining into that context, the context that's found in the field; is that right?
A Yes. I mean, it's also a skill set that allows me to work with others. So a lot of the analyses done in my lab are people who have brought samples to us, and so in those cases, I'm generating ages for them, but need to be heavily involved in helping them interpret it.
So that field-based skill set also allows me to ask them the appropriate questions to get at that interpretation or give them advice in advance about sampling strategies they might want to employ.
Q Okay. In your professional career, have you ever conducted any research on -- aside from the litigation context, on talc as a mineral?
A Not specifically focused on it, no.

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Q And same question with respect to asbestos.
A No.
Q Okay. How does a petrologist differ from a geologist?
A Well, there are geologists who are entirely focused on the fossil record or they might be really an expert in a certain kind of structural geology. So geology is more broad about, you know, the study of the earth and -- and rocks, whereas petrology, again, is really looking at the mineral assemblages and the mineral textures to get at how did that rock initially form and what are the processes that's altered it since its formation.
Q So you're not a professional geologist, I would assume.
A How do you define "professional geologist"?
Q Or a geologist generally.
A Oh, I'm definitely a geologist.
Q Okay. So the greater subsumes the lesser or the smaller.
A Petrology is a specific -- more specific area of geology.

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Q Of geology. Okay. Bad question. I appreciate it.
A Well, I -- yeah.
Q Have you ever published any peer-reviewed articles on asbestiform amphophiles in talc?
A No.
Q Have you ever presented on that topic in any capacity?
A No.
Q Have you ever published any peer-reviewed articles on the methodological approaches for the identification of asbestiform amphiboles in talc?
A No.
Q Have you ever presented on that topic?
A No.
Q Have you ever -- in the context of -- in the journal context, have you ever served as a reviewer?
A Yes.
Q Okay. Have you ever reviewed any articles or other materials on any issues involving asbestos in talc?
A Not asbestos specifically. I mean,

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there's been talc in rocks in papers that I've reviewed, but --
Q Okay. Specifically about the talc or --
A No. I mean, you know, again, that's part of an assemblage that's being interpreted in the context of the assemblage, et cetera.
Q Have you conducted any work with graduate students on any issues involving asbestos in talc?
A No.
Q Are you aware of any student thesis or dissertations on any issue involving asbestos in talc?
MR. FROST: Objection to form.
THE WITNESS: Am I --
BY MR. BURNS:
Q Aware.
A Aware?
Q Mm-hmm, generally.
A Yes.
Q Okay. And what's your general awareness?
A Well, I know -- I mean, some of the papers I've cited have come out are first authored by students who worked with Mickey Gunter, for

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example. I'm also aware of the Kerrigan thesis that looked at experiments in which they were seeing if they could grow asbestiform talc. So, yeah.
Q Putting aside the litigation context, have you ever participated in any discussions or fora or conferences involving those topics relating to asbestos in talc?
A No, not specific to them, no.
Q Have -- have you personally ever identified any asbestiform amphibole materials in a talc sample?
A No.
Q Have you ever examined any talc samples for that purpose?
A No, not for that purpose, no.
Q Have you ever examined any talc samples generally?
A Yes.
Q For what purpose?
A General petrology. I mean, if we're talking about rocks with talc in them, then we've seen some of that in the rocks from China and Papua, New Guinea, I think, but also in the petrology collection for teaching, putting

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together labs, et cetera.
Q Okay. Do you plan to offer any opinions in this case regarding the appropriate technique for examining cosmetic talc for the presence of asbestos?
A No.
Q Does your department possess a transmission electron microscope?
A The department does not. There's one in the medical school.
Q What about -- same question for a scanning electron microscope.
A There's one in the -- the medical school, and there's a new one coming this spring. I'm a co-PI on an NSF grant that was funded to allow UVM to purchase an SE/SEM instrument.
Q You said co-PI. What is a PI?
A Co-principal investigator. So there was a lead PI out of the physics department, and then I'm one of, say, five PIs on the grant.
Q I see. Have you ever been involved in research or work designed to investigate the presence of asbestos materials in any geologic formation?
A Not specifically for that purpose, no.

MR. BURNS: I think we're at a lunch stopping point.

MR. FROST: Yeah, 12:45, sounds about right.

MR. BURNS: All right. Great.

THE VIDEOGRAPHER: Going off the record at 12:41.

(Lunch recess.)

THE VIDEOGRAPHER: We're back on the record at 2:00 p.m.

BY MR. BURNS:

Q Good afternoon, Dr. Webb.

Dr. Webb, we are painfully close to checking off the qualifications box on this -- this little sketch I made.

Just one general question that I was hoping you could describe for us. When you go out into the field to collect samples, what process do you generally do when you go out there? What are you looking for? Can you describe that generally?

A Yeah, I mean, it depends on what's known and documented for the region already. So that -- you usually build off of the existing knowledge base. But -- so usually we're looking for fresh outcrops with 3D exposure so that you can actually

see something, rather than just a moss-covered rock surface, for example.

Again, to make observations about the -- the rock types, any observations that can made -- be made about the mineralogy in detail, but it depends on the size of the minerals in -- in the rocks. Again, looking to make observations and document structural orientations, again about the planar or linear elements that might be present in a rock as a function of its deformation history.

So, I mean, those are -- are generally the -- the sort of categories of -- of observations, yeah.

Q Now, when you take the specimen, how do you physically do that? Are you chipping off a specimen? Are you picking it up off the ground? I guess it really depends.

A I don't usually rely on things that are on the ground, because you can't. I've left plenty of rocks places where they didn't originate from.

So -- so usually it's a hammer and chisel, and most often I'm working with oriented samples. So we would measure a feature and mark it in the field, and that way we can reorient it

in the lab and, say, make -- cut the rock relative to a specific orientations.

Q And by orientations, are you referring to sort of how it was oriented in the ground before you took it so that you know where north, south, you know, up, down is?

A Uh, yeah, it depends. I mean, you know, so if -- if this is a rock and these pages are a planar fabric in the rock, the foliation will often cut perpendicular to the foliation so that you see the --

Q The layers.

A -- the layering rather than just looking at one plane in the rock. If there is a lineation, that usually relates to the deformations, so the transport direction of one piece of rock relative to a lower piece. And often we'll -- if that's present, we'll cut perpend- -- sorry, parallel to that, because that's how we would observe the rotation of minerals that might tell us the way the fault was moving. Or --

Q Okay. Thank you.

Now, you mentioned you would look for fresh outcrops or 3D exposure. What do -- what do

you mean by 3D exposure?

A Well, again, it's this idea that in order to make these -- what we would call kinematic observations relate -- how things are rotating, you need a rock exposure that allows you to look at an exposure that's perpendicular to the foliation and parallel to the lineation.

In other words, you could -- if something was rolling like that (demonstrative), you could --

Q Yeah.

A -- you could see that as opposed to it coming down the barrel at you. So that 3D aspect is important for getting those certain perspectives at times.

Q What type of sites do you look at or look for to find that, you know, fresh outcrops or 3D exposure? You had mentioned a road before.

A Yeah, so road cuts are -- are often our best window into the rocks, or perhaps in rivers. You know, yeah, I've certainly been in quarries before, et cetera, but --

Q Mines?

A If they're aboveground, I mean, yeah. I've never been in an underground mine.

Q Okay. Now, once you take the actual sample, I assume that you are taking it back to the lab to perform certain tests or examinations upon it. Right?
A Yes. Usually we take it back to the -- to the department, and there is a rock-cutting facility, so we'll cut those oriented chips out of the rock to send away to have thin sections made, petrographic thin sections.
Q And then what do you do with the petrographic thin sections?
A I look at them under a petrographic microscope, polarized light microscope, to make mineral identification, to observe the textural relationships between minerals. That, again, might relate to relative ages or metamorphic reactions that might be frozen or captured in a sample, and also the microstructural observations about, say, shear sense. As I said, the vorticity or the rotation of -- of minerals that might tell us about the type of faulting or deformation that was occurring. And then in the case of the geochronology, selecting appropriate rocks to target for dating.
Q And that's really been the focus of your

particular research is ultimately getting to that last point, the dating of those rocks, right?
A Not exclusively, no.
Q How not exclusively?
A Because I've had some projects where there's been no geochronology, and it's been more about the petrology, again understanding the temperature and pressure conditions. So, again, it just depends on what's known already and what the new questions are.
Q I see. And I take it during those steps of the micro- -- pardon me.
During those steps in the lab, you are carefully recording each of these observations; is that right?
A Yeah. I mean, again, it depends on what the -- the nature of the project is. But, yes, we make a record of the -- the mineralogy, the structures, et cetera, yeah.
Q How do you make a record of where the rock was sourced?
A Generally, we take GPS coordinates associated with the sampling locations.
Q Well, I think we can safely cross qualifications off our list.

And that will take us to the efforts you made in preparing to give your opinions in this case. And I'm going to get to those specific opinions a little bit later, hopefully not too much later, recognizing it is the afternoon.
What was your charge in this case? What were you asked to do?
A I was asked to study and -- and provide an explanation of the petrological processes that are associated with the high purity talc deposits. So, again, you know, these pressure, temperature, bulk composition type questions.
Of course, a specific question I was asked to address is what is the relationship or not of -- of asbestos to -- to the talc deposits at issue. Yeah.
Oh, as well, and part of that charge, of course, was to read and respond to the -- the reports of Drs. Cook and Krekeler. And also if there was information that I had or was able to synthesize on -- on, again, sort of at the mineral structure scale. The differences, for example, in the chemical resistance or the -- of, say, asbestiform amphiboles versus non-asbestiform amphiboles.

Q Mm-hmm. Can you describe in general terms the methodology you employed in reaching and rendering your opinions in this case?
A Yeah. So, I mean, I -- I really used the same approach that I would approach any aspect of my science, whether it's writing a paper or a peer review. But, again, to try and do an extensive search of the peer-reviewed literature, and also -- I mean, in that search I found also USGS reports, as we've discussed earlier today. And really to look in -- in detail, and, again, I mentioned that I tried to really dig into the primary citations, who were the first people to look at these rocks, what did -- you know, what did they see, and try and confirm things that had -- were then included in -- in later summary type papers that I also saw.
But, again, what I'm really concerned is as a petrologist is the system of rocks, and so, you know, not only was my interest related to anything written about the talc bodies themselves but also the surrounding rocks. Because in order to understand the history that the -- the talc ores experienced, you have to dig into rocks around them of different bulk compositions.

Different rocks have the potential to record different aspects, in part because they might have a different strength or they might have minerals that are more stable over a broader range of pressure and temperature conditions.

So this was all part and parcel in terms of trying to understand, as I was describing, the -- the structure of -- of the dome in the case of Vermont, you know, how differences between the core and those mantling units where the -- the talc mines are -- are located, the details of the pressure, temperature, deformation histories.

So, again, I wasn't only just looking at the talc ores, I was also looking at the reports of asbestos in Vermont and really trying to understand the petrology of those systems. Again, relative timing, pressure, temperature, conditions of formations, differences maybe that in fluid chemistry that might impact how metamorphic processes play out.

So, again, my synthesis was a range of scales from sort of, you know, all of Vermont and its cumulative tectonic history to, you know, reading works that described observations made in petrologic thin sections, you know, again, down at

the micron scale.

Q Okay. Well, one of the things that surprise me a bit in reading your report, just to be frank, is that the methodology you just -- just described and employed in this case differs from some of the science you have conducted before as a field-based geologist in that you did not apparently go out to, for instance, the Vermont sites and take samples, and bring those samples back to your -- to your laboratory to determine whether asbestos may be contained in the underlying rock, what that relationship might be to the talc.

Is that a fair description of what you did in this case?

MR. FROST: Objection to form.

THE WITNESS: I mean, I think the description of what I did is what I just outlined in the prior question. I mean, it's true I did not sample the -- the talc -- rocks from the talc mines, but again, I mean, as I've been describing, when I go out into the field, those objectives are -- are really driven by what I understand from the -- in this -- like in the case of Vermont, the decades of work of geologists and petrologists

before me.

So if there -- if I feel like there is a big gap in that information, that would drive that need to go out into the field to collect samples, and I just didn't arrive at that position in this case.

BY MR. BURNS:

Q Well, let me -- let me focus on the Argonaut mine for a moment. Are you aware of any peer-reviewed work or any other reports relating to samples taken in the Argonaut mine relative to talc and asbestos?

A The Argonaut mine. Well, other than, I think it's, the Buzon thesis where there were some samples that were analyzed by, I think it's, Marian Buzon during her Ph.D., I haven't seen anything in -- in the published literature about the samples from that mine except for her work, I believe.

Q So, for example, you spoke about gaps in the record. Why is that not a gap in the record you would be interested in?

A Well, again --

MR. FROST: Objection to form.

THE WITNESS: Again, I mean, basically

the Vermont talc mines that we're interested in are in a pretty specific zone around mantling that Chester dome, and so bracketing that history are -- is work done -- I mean, really the most detailed study out there is that Sanford 1982 paper, and Sanford sampled from, I think, three different locations in Vermont and also in Massachusetts. But in his study, he had samples from the Newfane mine and the Grafton mine, which basically bracket in PT space the -- the Argonaut, Hamm and Hammondsville mines, and so I was able to look at pretty gory detail in his -- in his paper.

I was able also to compare that with the -- the Pooley study, who sampled different rock types around the mine, which, again, was of interest to me because I like to work with rock systems. And he had detailed petrographic data and descriptions in there, again photomicrographs, the kind of -- the kind of data that I regularly work with.

And basically -- and also there was the Robinson -- or, sorry, the Robinson study from the Frostbite mine. And so, I mean, I feel like these rock bodies are -- are pretty tightly bracketed by these studies, and -- and I felt like I saw the

information I needed in those works.
BY MR. BURNS:
Q So we're sitting here today in Burlington, Vermont. How far approximately is the Argonaut mine from here?
A Oh, I guess two-and-a-half hours or so.
Q Driving by car?
A Yeah, driving.
Q Okay. And you realize that the -- the allegations in this case center in part on the plaintiffs' allegations that asbestos was a constituent mineral in the rocks that were mined at the Argonaut mine. Is that correct?
MR. FROST: Objection to form.
THE WITNESS: I'm sorry, can you repeat the --
BY MR. BURNS:
Q Sure. Just asking you, you realize that the allegations in this case center in part on claims that asbestos was a constituent of the material that was mined at Argonaut.
A Yeah.
Q Okay. Did you ever ask to go to the Argonaut mine?
A No.

Q Were you ever told that you couldn't go to the Argonaut mine?
A No.
Q And is that true of the other two J&J mines in Vermont?
MR. FROST: Objection to form.
THE WITNESS: Yeah, I mean Hammondsville is -- is underwater. It's a pond. So -- and I'm not sure about the Hamm. I think, you know, underground mining wouldn't -- or shafts wouldn't be able.
But, yeah, no, I didn't ask to go. I wasn't told that I should go or couldn't go. I was left to use my professional opinion about how that played out.
BY MR. BURNS:
Q I'm going to put up on the screen what I've marked as Plaintiffs' Demonstrative No. 2. I will give you and your counsel a copy of it, though, just so you can follow along.
(Webb Exhibit No. 18 was subsequently marked for identification.)
BY MR. BURNS:
Q I think I have a pretty good

understanding, although you should correct me if I don't, about this methodology you just described. But I want to make sure that we capture and exclude some -- some areas that I don't think fit into it.
MR. BURNS: Oh, did I -- yeah, those are two pages. Here.
BY MR. BURNS:
Q So I'm just going to ask you some questions, and I will -- I'll mark this so I can remember the answers.
So, Dr. Webb, have you ever worked in a talc mine?
A No.
Q Have you ever designed any talc mine operations?
A No.
Q Have you ever consulted on any talc mine operations?
A No.
Q Have you ever designed any drill core sampling protocols for talc mines?
A No.
Q Have you ever designed a blast hole sampling protocol for a talc mine?

A No.
Q Have you ever designed an open pit mining operation?
A No.
Q Ever designed an underground mining operation?
A No.
Q Have you ever supervised or consulted on the ongoing operation of a mine?
A No.
Q And I think I -- I think you've answered this, but have you ever visited any of the J&J talc mines in Vermont?
A No.
Q Is that also true of China and Italy?
A That's correct.
Q Have you ever conducted any field observations at any talc mines?
A No.
Q Have you ever conducted any field observations at any of the J&J talc mines?
A No.
Q Have you ever inspected any talc mines?
A No.
Q Or any J&J talc mines?

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A No.
Q Have you ever reviewed any petrographic maps from J&J talc mines?
A What do you mean by "petrographic maps"?
Q Well, similar to some of the maps that you included in your report but specific to in Vermont, Italy or Chinese mines?
A I mean, do you mean geologic maps? Because "petrographic" generally means observations made through a petrographic microscope. So petrographic maps to me would mean a map of a thin section.
Q I see. So that doesn't make a whole hell of a lot of sense.
A No.
Q All right. Fair enough. Well, I tell you what, we will scratch that one.
Have you ever reviewed any geologic map -- maps from a talc mine?
A Yes.
Q And what mine was that?
A There was -- in the Robinson, et al., 2006, report from the Frostbite mine.
Q Mm-hmm. Okay. How about any geologic maps from J&J talc mines?

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A No.
Q Did you ask whether any were available?
A I didn't ask, no.
Q Okay. Ever review any mine planning maps from a talc mine?
A No.
Q Have you ever reviewed drill cores taken from a talc mine?
A No.
Q Have you ever seen the drill cores taken from any of the J&J mines at issue here?
A No.
Q Have you ever reviewed any mine planning maps from the J&J talc mines?
A No.
Q Ever analyzed any thin sections from cores removed from a talc mine?
A No.
Q Same question with respect to J&J talc mines.
A Yeah, no.
Q Have you ever seen the results of any analysis of thin sections from cores removed from a talc mine?
A From cores, no.

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Q Same question with respect to J&J talc mines.
A Yes, that's --
Q Same answer?
A Yeah, yeah.
Q Have you ever inspected any core logs from a talc mine?
A No.
Q Ever inspected any core logs from the J&J talc mines?
A No.
Q Ever asked for any samples of J&J talc from the --
A No.
Q -- products in question?
A No.
Q I'm sorry. And that answer was "no"?
A Yes. Never asked for.
Q Okay. Have you ever taken any samples or rock specimens from a talc mine?
A No.
Q Or from the J&J mines in question?
A No.
Q Have you ever conducted any XRD on any J&J talc?

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A No.
Q What about PLM? We just talked about PLM a few minutes ago. Have you ever done that on any J&J talc?
A No, personally I have not conducted those studies.
Q Are you aware of any outside this litigation?
A Sorry, then we're on -- specifically on J&J talc?
Q Yes.
A And this is the bodies that are being mined for the cosmetic talc?
Q Yes.
A No.
Q Have you ever conducted any scanning electron microscopy on any talc?
A I've seen it, yeah.
Q Seen it, but have you conducted it yourself?
A Well, yes. I mean, again, not on the talc ores that we're -- we're discussing, but I've seen talc in rocks on the SEM while I've been --
Q So in other rocks.
A Yes.

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Q But not with respect to any J&J talc.
A No.
Q Have you ever conducted any transmission electron microscopy on any talc samples?
A No.
Q And that would be true of J&J talc samples?
A That's correct.
Q Have you ever seen test results from samples taken from the J&J talc mines?
A Test -- what kind of test results?
Q Test results with respect to asbestos or other contaminants.
A No.
Q Have you ever designed or supervised a beneficiation process for talc ore?
A No.
Q Have you ever published on talc deposits used to source J&J talc in Italy, Vermont or China?
A No.
Q And I think you answered this earlier, you've never published on asbestiform amphiboles in talc, have you?
A No.

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Q And is that also true of asbestiform serpentines?
A No -- I mean, you're correct, and the answer is no.
Q Have you ever published on methodological approaches to differentiate asbestiform amphiboles and non-amphibole minerals in talc?
A No.
Q And have you ever personally identified any asbestiform amphiboles in talc?
A No.
Q All right. Thank you, Doctor.
(Counsel conferring.)
BY MR. BURNS:
Q Now, recalling our discussion on your supplemental list earlier today, I noted that you had read the deposition and expert report of Ann Wylie.
Have you ever discussed this case or your findings with Dr. Wylie?
A No.
Q Have you ever spoken to Dr. Wylie before?
A Last summer, once I spoke to her on the

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phone, I think.
Q Okay. And what was that about?
A I was curious where I could access some of her data on some of the -- the studies she's compiled or done, so the WebLink distributions, et cetera.
Q Anything else in that conversation?
A No.
Q And was that the only conversation you've had with her?
A That's the only time I've spoken with Ann Wylie.
Q And was that in the context of discussions about asbestos, the conversation you had with her?
A Yeah, so the -- I was looking for the -- the data from both known -- you know, like the -- the standards -- known asbestos versus known cleavage fragments.
Q Did Dr. Wylie inform you that she was serving as an expert witness in this litigation?
MR. FROST: Objection to form.
THE WITNESS: It was prior to this, so neither of us knew.
BY MR. BURNS:

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Q And you haven't spoken to her since your reports came out?
A No.
Q All right. I also noticed you had read the deposition and expert report of Mary Poulton, Dr. Mary Poulton.
A Yes.
Q Have you ever spoken to Dr. Poulton about asbestos in talc?
A No.
Q Any conversations with her whatsoever?
A I've never met her or talked to her, yeah.
Q And you also reviewed the expert report of Dr. Darby Dyar; is that right?
A That's correct, yeah.
Q And have you spoken with Dr. Dyar?
A I met her in October of 2018, I believe, because she was invited to come give a seminar in our department.
Q What was the seminar of?
A It was related to her work on Mars, that program.
Q Did you discuss anything with respect to asbestos or talc?

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A Not in great detail. I mean, I -- I took her to lunch, and we were having a conversation about the general paths of our -- our careers, and so we understood that we were both working with J&J lawyers. But, again, that was prior to this case, and we didn't go into any details.
Q Any specific conversation about asbestos and the talc in J&J mines?
A No.
Q And going back to your conversation with Dr. Wylie, why were you interested in the data you were asking her about?
A Because -- well -- yeah, so I was just doing general consulting, meaning I was doing some research to bolster my understanding of the topic, and, you know, occasionally I was asked to respond to a document or a paper. And so I had seen some of Dr. Longo's reports, and so there was an analysis that -- in one of his reports that related to the size distributions of -- of structures he was measuring with -- with the TEM. And so I was curious about that topic and wanted to explore it further on my own.
Q And who provided you those reports?

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A Those would have come from Jonathan Cooper.
Q And who's Mr. Cooper?
A He's with Tucker & Ellis.
Q So after receiving that data, what did you do?
A I -- I basically -- I mean, with Ann's data or ultimately with the online datasets that they've published, I was able to bring that into Excel, and so I was exploring different methods of plotting the data, aspect ratio versus width or width versus lengths or, you know, the variety of ways, log, normal, just -- not -- excuse me. Pardon me. So, yes, it was sort of an exploration in plotting methods to see what seemed to be most meaningful.
Q And what do you mean by "most meaningful"?
A Well, I mean, in particular, looking at Ann's data, cleavage fragments versus known documented asbestos, seeing if there was a plotting method where you could see a clear distinction in populations.
Q I see.
A I mean, not in a single particle, but,

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again, looking at a data -- a large dataset, what were the --
Q Okay. And did you reach any conclusions?
MR. FROST: I was going to say --
THE WITNESS: Yeah, this is --
MR. FROST: -- I'm going to caution you to the extent that -- we're now reaching into consultancy, which has nothing to do with her work here.
I'm just going to caution her, you know, obviously any communications you've had with lawyers during the consultancy and any work product that you created during the consultancy, I'm going to instruct you not to answer on that. But if it's something that you drew yourself, you know, sort of separately from what you were working with the lawyers on, you know, that you can answer.
THE WITNESS: Pardon me. I have an eyelash attacking my eyeball.
BY MR. BURNS:
Q That's okay. Do you need to take a break or --
A I'll be fine.

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Yeah, I -- honestly, I haven't reviewed that in preparation for this. It's not part of the opinions I'm -- or I offered in my report. So I'd rather not comment on that without having refreshed my memory of those graphs.
MS. O'DELL: If the data has been provided to Dr. Webb, we would request on the record that the data from Dr. Wylie be provided to us. I will formalize that request after the deposition, but I think we're entitled to it if she has reviewed it.
MR. FROST: Again, I think she just said she didn't consider it as any part of this opinion, so I actually -- I will lodge an objection to that. And moreover, I think she testified that she had a link to online data sources that she looked at.
So to the extent that you are insinuating she was provided data by Ann Wylie, I think that is other than what the record reflects here.
MS. O'DELL: I think the record is quite clear, and regardless of that, it was not disclosed --
MR. FROST: And --

MS. O'DELL: And if it's available publicly, that's one thing, but we have to know that she's been provided that data. And so we would request that it be --

MR. FROST: And I guess I'm just failing to understand why we would have to produce you data that has obviously nothing to do with this engagement. You can send a letter, but, you know, obviously we object to it.

MS. O'DELL: We will let the court decide about that.

MR. FROST: That's fine.

But again, I think she's made it very clear this has absolutely nothing to do with what she's been engaged to do.

MS. O'DELL: Please don't coach the witness.

MR. FROST: Please don't what?

THE REPORTER: I couldn't hear you.

MS. O'DELL: Please don't coach the witness.

MR. FROST: I'm not coaching at all. I'm responding to your statement on the record.

BY MR. BURNS:

Q What was -- what was the form of the

Longo reports that you had at the time?

MR. FROST: Objection to form.

THE WITNESS: The form of the Longo -- I mean, they were PDF documents that kind of mimicked the format of -- of this. So...

BY MR. BURNS:

Q And this was the summer of 2018?

A I would have to -- that's a -- I mean, my best guess for the general time frame, but I don't remember details.

Q And do you recall whether they were taken from litigation or --

A Oh, they were -- yeah. I mean, they were expert reports, so...

Q Okay. Do you know Dr. Brooke Mossman?

A I've met her once, yeah, or twice now. I ran into her in the parking lot. So...

Q Have you had any conversations with her about this case?

A No.

Q Have you had any conversations with her about asbestos in talc?

A No, not specifically.

Q Do you know a Dr. Shukla, I think in her department?

A I'm familiar with the name, but I've never met or talked or communicated with her.

Q You mentioned Mickey Gunter earlier?

A Yes.

Q Is that right?

What is your relationship with Mickey Gunter?

A Well, shortly after I came to UVM, he had a -- a Marsh Fellowship, I think is what they call it, but it's basically an honorary visiting professorship. So he's -- it might have been 2009, around that time, that he was in our department maybe for a couple of weeks at a time throughout the -- the year. So that's when I met him.

Q I see. And have you continued a friendship or professional relationship with him since?

A I haven't talked to him since that March Fellowship, so not in eight years or something like that or -- yeah.

Q Have you communicated with him by e-mail or any other means?

A No.

Q No. Dr. Webb, I think we can mark off

preparation.

A Very good.

Q One left.

MR. BURNS: Should we take a short break?

THE WITNESS: Yeah. Fill my water glass.

THE VIDEOGRAPHER: Going off the record at 2:42 p.m.

(Recess.)

THE VIDEOGRAPHER: We're back on the record at 3:10 p.m.

BY MR. BURNS:

Q Welcome back, Dr. Webb.

Dr. Webb, were you aware that -- that Dr. Mickey Gunter serves as an expert witness for J&J?

A I am aware of that, yes.

Q How did you become aware of it?

A I mean, I knew in general of his involvement as an expert witness from when he visited UVM long ago, but -- I suppose like the details of his working for J&J came out sometime during the consulting. I mean, seeing documents, et cetera.

Q All right. Dr. Webb, at long last we've made it to the report section.
MR. BURNS: Are you okay?
MR. FROST: Yeah. I just kicked the table pretty hard.
MR. BURNS: That's no fun.
BY MR. BURNS:
Q So I'd like to direct you to, I believe, Exhibit 1. And is this a true and correct copy of your expert report?
A It appears so, yes.
Q All right. And did you prepare this report yourself?
A I did, yes.
Q Did you write every word of it?
A I did, yes.
Q Now, one of the terms that appears throughout your report -- and we'll get to the certain instances of it, but we've also -- I've also heard you mention it today -- is you've emphasized, I believe you call it, high purity talc or cosmetic grade talc deposits.
A (The witness nods.)
Q Can you explain what you mean when you're using that term?

A Well, I -- I guess I'm making the distinction between a rock that has talc in it or a rock that may have abundant talc in it versus something that is talc rich enough that it would be of interest for the mining companies.
Q And is that really the trigger whether it's -- whether industrial use -- it's capable of industrial use or extraction?
MR. FROST: Objection to form.
BY MR. BURNS:
Q I don't want to put words in your mouth.
A Yeah.
Q I'm just really trying to tease out what you mean by that.
A Well, I mean, I think there are definitions for "cosmetic grade talc," and I know that it reflects -- maybe after a beneficiation, the purity levels that are -- you're able to attain coupled with some other geochemical requirements and in the absence of asbestos.
But I think, you know, one of the distinctions I'm trying to make is a rock that has talc in it versus something that has undergone such extreme degrees of metasomatism that we arrive at the deposits that we have in Vermont and

Italy and China.
Q Mm-hmm. Would it be fair to say then that that high purity grade of talc deposit is one that is, for lack of a better term, pure enough to attract the interest of industrial or cosmetic purposes?
MR. FROST: Objection to form.
THE WITNESS: Yeah, I mean, they wouldn't be interested in something that wasn't rich in talc and, yeah, relatively high purity.
BY MR. BURNS:
Q So let's say you had a deposit where for every pound of talc you extracted, there was another pound of waste. Would that fall into that category for you?
MR. FROST: Objection to form.
THE WITNESS: Yeah, I don't know. I mean, that kind of gets beyond my area of -- of expertise and distinction, I think. Because, yeah, I'm not an expert in the mining process, and --
That eyelash came back. Sorry.
BY MR. BURNS:
Q Sure. Oh, no.
I guess another way to look at it -- and

really, again, I'm just trying to understand -- but for this purpose, the only mines you were looking at were in your view high purity deposits because they were used as mines for the talc industry. Is that fair?
MR. FROST: Objection to form.
THE WITNESS: Well, I mean, they're -- so obviously it boils down to my opinion about the mines that were used for the talc that was used in talcum powders, and -- but I was actually looking at a larger body of literature to kind of understand the systems and -- and sort of bracket again these conditions where these rocks formed.
BY MR. BURNS:
Q Just to be sure that I don't miss it if there is a distinction, the J&J talc mines -- what we've been referring to as the J&J talc mines are all in view -- in your view, high purity deposits; is that right?
A Well, yes. Deposits from which cosmetic grade talc can be derived.
Q Okay. And so we've talked about those three mines in Vermont. We've also mentioned some other mines around there, the Johnson mine, Rainbow mine. Would you consider those high

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purity talc deposits as well?
MR. FROST: Objection to form.
THE WITNESS: Yeah. I mean, there may be zones of -- you know, so even the Newfane mine has high purity talc zone in it, but the Newfane mine, that zone is so thin, I think it wasn't economically viable. So it could include mines from which there is no active or was no active mining based on the economic viability of it.
BY MR. BURNS:
Q Okay. So I would like you to turn to page 1 of your report, which contains the executive summary.
A Okay.
Q So as its title indicates, I take it this section summarizes your opinions that you are prepared to testify to in this litigation.
A Yes. An overview of them, yes.
Q Okay. I'd like to start with subparagraph A in Section 1.0 of the executive summary.
So subparagraph A begins with the statement: "Plaintiffs' experts' reports fail to appropriately synthesize key data and observations available in the peer-reviewed scientific

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literature that are pertinent to understanding the issues in this litigation."
Did I read that correctly?
A Yes.
Q Okay. What -- first of all, what plaintiffs' experts' reports are you referencing there? Is it Dr. Cook and Dr. Krekeler?
A Correct.
Q Okay. Any others?
A No.
Q Okay. It's not Dr. Longo?
A No.
Q Do you have any opinions with respect to Dr. Longo's work?
A Not that I'm offering in this report or today, no.
Q Have you -- do you intend to offer opinions with respect to Dr. Longo in the future?
MR. FROST: Objection to form.
THE WITNESS: I mean, I think it depends on the questions that are -- are asked. But that really wasn't my charge to respond to his report, and so, yes, I did read it, but --
BY MR. BURNS:
Q Do you have any criticism of Dr. Longo's

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report today?
MR. FROST: Objection to form. Outside of the scope of this witness's opinions.
THE WITNESS: Can -- can I answer or --
MR. FROST: Yes.
THE WITNESS: Sorry.
MR. FROST: Unless I specifically instruct you not to answer, you can answer.
THE WITNESS: Okay. I mean, yeah, my experience -- for example, anthophyllite and talc have very similar geochemistry -- or, sorry, chemistries that, in general, EDS is not sufficient to distinguish the two. And -- and he never provided quantitative data based on the EDS analyses, and so, you know, there are -- are issues there that I -- I take issue with.
I would also say that I'm not an expert in SAED, so I'm not going to go down that road at all.
Some things that are shown in the TEM images look much more like cleavage fragments to me than asbestos fibrils or bundles, but -- but I guess -- so it's my general reaction to the use of the EDS data, and -- yeah, and the -- and the assertion that some of these amphiboles that

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presumably are identified in there based on the other analyses are -- are asbestos.
BY MR. BURNS:
Q Okay. Anything else?
A No.
Q All right. You next say that Dr. Cook and Dr. Krekeler, the plaintiffs' experts you refer to, failed to appropriately synthesize key data.
What data did you have -- do you have in mind there?
A Well, I mean, the -- the details of the geology of Vermont, the details of the metamorphism recorded by the rocks in the region of -- of interest, they basically present broad generalizations from some of these papers that present generalizations, and, you know, try to make analogies between rocks in the southern Appalachians, and I think the mines in Vermont are a very different beast than the ultramafic bodies that are -- are elsewhere throughout the orogen.
Q Okay. What about Italy and China?
A Yeah, so with China, I didn't see them zeroing in on the -- the Guangxi mines that were actually used. There -- I know Krekeler, I think

specifically more than Cook, at least what I remember offhand, is that, you know, a lot of his discussion included mines that were thousands of kilometers away off in the Shandong Peninsula that were totally irrelevant.

So, again, it's the lack of detail related to petrological evolution in the immediate vicinity of -- of the mines from which the talc was derived.

Q And you next question the observations available in the peer-reviewed scientific literature that are pertinent to understanding the issues in this litigation.

Is your use of data and observations there somewhat synonymous, or are you drawing a distinction?

A I mean, there -- yeah. I guess it's redundant in a sense.

Q Not criticizing.

A Yeah.

Q Okay. Just trying to understand whether there is a unique distinction there.

You reviewed, and I can't remember the precise number, quite a few articles and reports with respect to the geology of Vermont. Is that

fair?

A Yes.

Q Okay. Do any of those reports stand out to you as particularly sound in terms of their methodology, their primary sourcing, et cetera?

MR. FROST: Objection to form.

THE WITNESS: Particularly sound? Well, certainly, as I mentioned before, the Sanford 1982 article really is the -- the piece of literature out there that looked into the systems in which talc is forming in -- in these rocks. You know, it's really, again, kind of putting together the body of data.

But I will say Chidester comes up. There -- there are a number of -- of articles that make this same statement, and this is what I think is key, is that -- again, there's a polyphase tectonic history. So we've got three big orogenic events that kind of build up the geology in Vermont and influence it.

And the people who have looked at those rocks -- so Chidester said it, Sanford said it -- those are the two that really come to mind -- is that when they look at the relationship between where asbestos is formed and where the talc is

forming, they see information that is very clearcut that they are not part of the same event. And that is, that the asbestos forms during late -- presumably in the tectonic orogeny when these rocks are at low temperatures, low pressures, they're -- these ultramafic bodies, which were, you know, basically the rock collage when it was kind of assembled at that time for a large part, especially the bodies where the asbestos is documented.

So in the late stages of the tectonic orogeny about 450 million years ago, that's when these ultramafic rocks are forming brittle fractures. Water rich fluids are interacting with them. Serpentinization is occurring. And that is when the chrysotile asbestos forms. And the few instances that are documented of tremolite asbestos are also part of that same event.

Now, the talc, as I said before, forms during the Acadian orogeny, so that's 80, 90 million years later, under very different conditions. And I would also say that the rocks from which the -- the cosmetic talc is derived in Vermont is in a different geologic belt than the asbestos-bearing rocks.

But in any case, if -- you know, so the -- the Acadian orogeny event where the talc is forming is at much higher temperature conditions. The rocks are deforming ductilely. There's this intense metasomatism that's going on, and that is the diffusion of chemical elements across these rock boundaries that is basically changing the composition of the ultramafic rock to something that's much closer to the talc composition.

That's why I have those weird triangle diagrams in my report to demonstrate that. Sorry, they're not weird to me, but I know they're odd to others, a non-petrologist. I'll clarify that.

And so we really have, again, a different set of conditions. The fluids are water and carbon dioxide rich in the Acadian orogeny. And, again, there's no asbestos as far as I've been able to determine that are recorded in those rocks in any clearcut fashion, but, say, had chrysotile been present in the ultramafic bodies from which the talc formed, it would have been erased by that -- that metamorphic process.

So this is why I say I don't see any documentation of it, nor were the conditions appropriate. Because, again, where it's been

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documented, it's -- asbestos is forming under -- in different places in space and time and under different conditions than the -- than the talc forms.
BY MR. BURNS:
Q Okay. So just to be clear, it's your opinion that you've not seen any evidence of asbestos in the J&J talc mines that we have been discussing, right?
A That's correct.
Q Okay. Is it your opinion that there is no evidence of asbestos in those J&J talc mines?
MR. FROST: Objection to form.
THE WITNESS: It's not been demonstrated to -- no evidence has been demonstrated to me in the -- in the literature or the reports that I've reviewed.
BY MR. BURNS:
Q Okay. Let me ask you a follow-on question then.
Is it your professional opinion that it is impossible for asbestos to exist in the talc sourced from the J&J talc mines?
MR. FROST: Objection to form.
THE WITNESS: It's extremely unlikely.

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BY MR. BURNS:
Q But not impossible?
MR. FROST: Objection to form.
THE WITNESS: Geologists don't like using the word "impossible," but I would be extremely surprised.
BY MR. BURNS:
Q Can you in your professional opinion imagine circumstances where the chrysotile or tremolite asbestos made its way into talc deposits and was not erased by that process you were describing?
MR. FROST: Objection to form.
THE WITNESS: Not in the local geology.
BY MR. BURNS:
Q Not in Vermont.
A Not -- yeah.
Q How about -- and, again, focusing on Vermont here. We'll get back to China and Italy.
So focusing on Vermont, have you seen evidence of fibrous talc in the talc that was sourced from the J&J mines?
MR. FROST: Objection to form.
THE WITNESS: I've seen evidence of fibrous talc recorded in the thin section

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descriptions. Again, I wasn't looking at the finished products. So I don't want to offer opinions on those, but --
BY MR. BURNS:
Q You mean you haven't actually seen the thin sections. You're -- you've read descriptions of them in the findings. Is that what you're saying?
MR. FROST: Objection to form.
THE WITNESS: In the literature and reports that I reviewed, that's what I'm summarizing, yes.
BY MR. BURNS:
Q Do you have any opinion as to the -- as to whether the appearance of fibrous talc would be common in the talc sourced from the J&J mines?
MR. FROST: Objection to form.
THE WITNESS: It could be present.
BY MR. BURNS:
Q In sub- -- in substantial quantities?
MR. FROST: Objection to form.
THE WITNESS: I have no -- I mean, I think they are principally -- my understanding is they are principally looking for platy talc, but, you know, so in rock bodies dominated by that, you

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can't rule out the -- the local presence of a fibrous talc.
BY MR. BURNS:
Q So it could be present.
A Yes. I mean, we know it forms from often -- I mean, a fibrous morphology again is the result of the way the metamorphic reaction proceeded, so those reactions are documented in these rocks. So, yes.
Q Let's focus on China for a moment and the Guangxi mines. What is your -- is your opinion the same with respect to those mines as it is with the Vermont J&J mines?
A Yeah. I mean, they formed in a different bulk composition and a different system, but at similar metamorphic grades and with similar principles at play. And once again, I never saw anything in the literature related to the local geology around those mines to support an assertion of the presence of asbestos.
Q Did you see anything in the literature related to the local geology of those mines?
A Yes.
Q What was that?
A Well, so -- I mean, I cite the papers

that I -- I looked at. But basically that region is -- is described in some detail in studies of -- and people who were again looking at the tectonic evolution of the rocks, but -- say Yao, et al., 2016, which is where the map figure is derived, the Guangxi mine plots within that -- that mapped area, and the formation of talc in those units is described in the literature.

Lee, 1979, actually documents that in detail and explores the -- the metamorphic reactions involved in generating the -- the talc.

So, yes, there is -- there are descriptions of the local geology in -- of the units that are bracketing the talc bodies and from which the talc was derived or formed.

Q But none of those are specific to the Guangxi mine; is that right?

MR. FROST: Objection to form.

THE WITNESS: Oh, well, I mean it is specific to them. This is the area that the -- the mines are located. It relates to the units that are documented in the -- the IMS documents that describe the mines. So...

BY MR. BURNS:

Q I guess I -- maybe I did not phrase that

quite the way I should have.

But, again, those descriptions are on a regional level, right? They're not specific to any particular mine or samples from that mine, correct?

MR. FROST: Objection to form.

THE WITNESS: They're specific to the local geology around those mines.

BY MR. BURNS:

Q Is the local geology similar to the geology found here in Vermont?

A I mean, it's a -- it's a different -- it's a different continent. It's got a different history. In this case you have dolomitic marbles that were juxtaposed next to mafic igneous rocks that underwent a tectonic episode 400-something million years ago, where there was ductile deformation associated with the faults that are shown on -- on the map. And you had silica rich fluids present during metamorphism. And so, again, it's a case of metasomatism, a case of chemical exchange.

So some elements of the process are the same or similar, but the -- the details of the geology and the rock types are -- are quite

different when you're talking about the -- the genesis of the talc itself.

Q What was the nature of the underlying rock? Was it ultramafic or chloritic?

MR. FROST: Objection to form. Where?

BY MR. BURNS:

Q In China.

A Yeah. So, again, dolomitic marbles juxtaposed next to these mafic igneous rocks that underwent greenschist facies metamorphism. So, again, that's in that range of, say, 500 -- around 500 degrees C.

So, yeah, in some of the mafic units, I mean, there -- yeah, there's -- there's chlorite present locally. They -- they don't describe the same blackwall zones, and that's again because the rock types are different. So...

Q And what is a blackwall zone?

A It refers -- well, so in -- in Vermont, it refers to the -- the zone that's right at the contact of the ultramafic rocks and the country rock, and so there are chlorite and actinolite rich domains. In some cases, also biotite, which would truly give it the black color. But they would be very dark rocks in comparison to the talc

rich rocks that they're juxtaposed with.

Q I'll hand you what we'll mark as Exhibit 11.

MR. BURNS: I think we got these from your materials. Is that where they came from?

MR. FROST: Yeah.

MS. O'DELL: Yeah.

MR. FROST: Yep, that's fine. I know what this is.

MR. BURNS: Okay.

(Webb Exhibit No. 11 was marked for identification.)

BY MR. BURNS:

Q Is that the document, Exhibit 14, that you relied on for your opinions with respect to China?

A It's one of the documents.

Q Okay. Now, that is in Chinese. Do you read Chinese?

A I know a few characters.

Q Okay. Is there an English translation that you relied on or --

A I asked counsel if -- if that service would be available for this document, and it was provided.

However, even prior to that, though, I was able to correlate the -- the map unit names that are not in -- in Chinese, and so able to deduce -- I don't have it. I'd have to refer to the series of documents to point out, but, you know, the geologic layer in the map that was associated with the -- the talc formation.

And there are also some chemical reactions that are written in English characters, and so I can read -- read those. But -- but, yes, the details of -- that are hidden in the Chinese characters, I relied on the translation for that.

MR. BURNS: And, Mr. Frost, can you provide that?

MR. FROST: I'm sure I can find it. It might even be in the box.

MS. O'DELL: Do you know how we would identify it? Is it --

MR. FROST: It would say "Lee." I mean, I think I could find it in electronic form, and I'll e-mail it to you.

MS. O'DELL: Okay.

MR. BURNS: Thank you.

MR. FROST: That might be the easiest way to dig it out.

MS. O'DELL: Eric, can you do the translation?

MR. FROST: He might be able to. Alex.

MS. O'DELL: Alex.

BY MR. BURNS:

Q You said that was one of the documents. What was the -- what were the others?

A Yao, et al. Zhao, et al. Yao, et al., 2016. Zhao, et al., 2018.

MS. O'DELL: Do you mind spelling those, please?

THE WITNESS: Yao, Y-A-O, et al. And Zhao, Z-H-A-O.

MS. O'DELL: Thank you.

BY MR. BURNS:

Q What about the peer-reviewed literature allowed you to reach the same conclusions with respect to Italy?

A Well, so in Italy, there's actually more direct description of the, I'm going to say, Fontane, and it's probably pronounced differently in Italy. I'm better with the Chinese pronunciations than the Italian.

So there are a number of publications, albeit it a small number, but that do describe

these deposits directly. There the talc formed early in the history of -- of the rocks. Because, again, I mean, the -- this -- this region has, again, a very complicated history represented by hundreds of millions of years, and, you know, they're in the Alps today, but that is a Cenozoic collision orogenic event that built up those mountains.

But the -- the people, again, who studied the minerals present, their textural relationships relative to one another, the different structural elements and their relative age relationships, all demonstrate -- I mean, it's pretty much a consensus out there that the talc formed in this pre-carboniferous basement. So, you know, the constraint in the literature is around 355 million years or -- or prior.

And the mineral assemblages, again, not the talc specifically but in the rocks, the system of rocks in which the talc is embedded record evidence for metamorphism at up to like 575 degrees C or so, 600 degrees C, during an older orogenic event. And then talc being very stable, unless you achieve temperatures much higher than -- I mean, close to 700 degrees or higher,

that talc basically went for a ride down a subduction zone and came back up.

So that's why I'm familiar with the area generally, because it's another case of one of these ultra high pressure terrains like I studied for my Ph.D.

But, again, it's a mesomat- -- well, there's kind of two theories out there in terms of either the talc formed from a sepiolite horizon, which has a chemical formula very similar to talc. So that transformation would be just a function of sepiolite having gotten hot enough to react to form talc.

But the relationship between -- of the talc bodies basically being at this interface of, again, carbonate rocks and mafic gneisses suggest to me, rather, that it was again a case of metasomatism, a chemical exchange across rock boundaries during high temperature metamorphism that allowed the transformation of volumes of rock to basically move towards that talc composition.

So, again, it's the integration of what people have seen in terms of mineral assemblages, textural relationships, relative age relationships, et cetera, that led me to my

opinion.
Q And what are your principal sources for your Italian theories -- or, sorry, opinions?
MR. FROST: Objection to form.
THE WITNESS: So could -- those papers that I cite here, Cadoppi, et al., 2016; Sandrone, et al., 1990; Sandrone and Zucchetti, 1988. There's Del Greco and Pelizza, 1984.
BY MR. BURNS:
Q Are there any that are not cited in your report?
A I don't believe so. I mean, if they are, they would be in the reliance, but I think this is the key body of the papers.
Q Oh, Exhibit 14, that Chinese document, how were you able to locate it or find it?
A I don't remember whether it was with GeoRef or using Google Scholar, but I -- you know, searching again the scientific literature, and -- specifically for -- so this is why I asked for the -- the Imerys China mine documents was -- I used those to get the formation names at the mines of interest, and then I searched the literature for those formation names.
The -- the Imerys documents also had

coordinates of the mines in some cases, and so I used those geographic coordinates to, for example, determine that I was looking at the same geology that's shown in this map figure.
Q Okay.
A Or, rather, that the geology shown in that map figure described in those articles was relevant to the mines.
Q So turning to subparagraph C on the first page of your report, you say: "There is no well-founded, scientifically sound evidence in the peer-reviewed scientific literature for an association of amphibole asbestos with the talc deposits of concern."
So I think we've run through the literature you consider well-founded.
Is there literature out there in the peer-reviewed scientific literature that you don't consider well-founded or scientifically sound that supports the association of amphibole asbestos with the talc deposits of concern?
A I've never seen anything in the published peer-reviewed literature that implies specifically that there is asbestos in these -- these talc mines.

You know, part of, I guess, what I'm responded to are summary papers like Van Gosen, et al., 2004, that at kind of a surficial level, if you read that paper, you would come away with the impression that it was highly probable.
But, again, when you dive into the details of the geology and you really start to understand how these very unique bodies formed, there's just -- there's just nothing that would lead you to that association.
Q What about Doll? Anything in Doll that you consider not scientifically sound or --
A The Doll, 1961?
Q I think that's the right year.
MR. BURNS: Do you have that handy?
MS. O'DELL: It may be '65.
THE WITNESS: I'm not sure I cited that or --
BY MR. BURNS:
Q It's in your materials. Let's take a look. '61.
MS. O'DELL: '61.
MR. BURNS: '61.
THE WITNESS: I mean -- sorry.
BY MR. BURNS:

Q Go ahead.
A Is that the -- so is that the question, Doll 1961?
Q Yeah, that's the question. I think it's '61. Mm-hmm.
A Doll 1961 is a published bedrock map of Vermont.
Q Mm-hmm.
A So it is the version that existed prior to the update, which is Ratcliffe, et al., 9 -- or 2011.
So, yeah, some things have changed. There's been some new -- new mapping, some new age data that's come out, so, you know, things have shifted, but that was the state of knowledge at that time.
Q Mm-hmm.
MR. BURNS: What's that?
Leigh, I think you said it was 20.
MS. O'DELL: 20.
MR. BURNS: Yeah.
(Counsel conferring.)
BY MR. BURNS:
Q Oh, I see. I thought it was the statement of the geologist at the time.

We're referring to bedrock geology of the Woodstock quadrangle in Vermont by Chang, Ern and Thompson. Are you familiar with that?
A Was that 1965 or thereabouts? I know I made reference to one Chang article.
Q Judging by the font, 1965, you're right.
A Sorry. I'd just like to find that in my report.
Q Sure.
MR. FROST: Did you say it was Chang, C-H-A-N-G?
MR. BURNS: Yeah.
THE WITNESS: Right, I think this -- my citation to it relates to the Five Corners mine.
BY MR. BURNS:
Q Okay.
A On page 21.
Q More broadly, is this an article that you considered to be well-founded? Sound -- scientifically sound?
A Well, it's -- I wouldn't say I would venture an opinion on the entire body of that document. I -- again, I looked at that specifically with respect to Van Gosen's 2006 citation. Or maybe he -- no, I forget. Did he

actually even cite that and I came across it myself?
Okay. So I found a reference to chrysotile in the Five Corners mine in that -- that document. But Van Gosen actually did not include that one.
I mean, I don't -- I don't take issue, you know, with --
Q Okay.
A -- chrysotile at the Five Corners mine.
Q Any other criticisms of that article you recall?
A Not that I think are -- no.
Q Let's turn to page 13.
And I'm looking at Figure 7. I believe this is chemographic diagrams for the -- oh, geez -- calcium oxide, silicon oxide, magnesium oxide -- chemical system for calcareous and ultramafic rocks modified from Winter, 2001.
Is that correct?
A Yes.
Q Okay. How was it modified?
A Well -- I think I added color. I also I think added the position of actinolite, which would plot similarly to tremolite in this system,

if there were enough iron for actinolite to form.
I also, you know, basically then took a subset of that figure to -- for just a smaller demonstrative and a smaller version of the chemographic diagram in the upper left.
Q Mm-hmm. Okay.
A But, otherwise, it's -- it's pretty -- pretty similar.
Q Is this diagram -- and forgive me for being confused on it -- but would this diagram be accurate for the J&J mines in Vermont?
A Actually, it would, because those ultramafic bodies are extremely magnesium rich. And so -- yeah, I mean, that ultramafic bulk composition, based on the data that have been published for a larger and more unaltered body in Ludlow and Dover, would -- would plot where that -- that purple triangle is.
THE REPORTER: That what? I'm sorry.
THE WITNESS: Sorry. Where the purple triangle is in the diagram.
BY MR. BURNS:
Q Did you plot this for Italy or China?
A I did not.
Q Would it differ?

A Yeah, I mean, those again would be a little bit more -- the general principle I'm trying to -- to show here holds in the sense that in order to make a talc ore, you have to have sort of extreme metasomatic events to change the bulk composition of the rock to something that is very close to -- to talc.
So in principle, it fits, but in terms of that, of that system, because it's limestones and marbles juxtaposed next to schist, and then mafic, but not ultramafic, the -- the chemical components you would need to consider would be slightly different.
Q How would it change the plotting? What would be the effect?
MR. FROST: Objection to form.
THE WITNESS: Yeah, well, you would probably need to combine some chemical components. Again, this is -- this is assuming that, you know, you've got these three components that are shown at the apices of the triangle are dominating the system.
So, depending on what those chemical components would be, you would have different minerals and minerals plotting in different

positions in that diagram compared to what they are here.
BY MR. BURNS:
Q And do you have sufficient data for Italy or China to plot something similar?
A No. And -- I mean, I could find that, but again this -- the purpose of this was really to try and illustrate the point that while you can have talc in carbonate or ultramafic rocks, with a variety of minerals in your sort of general metamorphic rocks, it takes a special process to make a talc ore.
So, you know, I didn't engage in an analysis with this beyond that. It was meant more to -- to try and illustrate a key concept.
Q Let's go back --
MS. O'DELL: Jack, would you please provide White, 2001.
MR. FROST: If I have it.
MS. O'DELL: It's not --
THE WITNESS: It's a textbook.
MR. FROST: Oh, is that what it is?
THE WITNESS: It's a geology textbook.
MR. FROST: Yes. I don't have it, but I'll see if we can do anything during a break.

MS. O'DELL: That would be -- that would be good.
MR. FROST: Yeah, no promises, though. I can't guarantee I can get it.
MS. O'DELL: Well, I mean if she is relying on it, and it's something she has based a figure in her report, then we requested those materials. So I understand the issue, but if you could work on it.
MR. FROST: As I said, I'll see -- I'll see if we can --
MR. BURNS: And I think you're referring to Winter, right?
THE WITNESS: Yes, Winter.
MR. FROST: I was going to say --
MS. O'DELL: Excuse me. Excuse me. Winter.
MR. FROST: Winter, I've got a better shot of finding, so at least I know what that is. But I don't know if I can get it, but I'll see what we can do during a break.
MR. BURNS: Winter is coming.
MR. FROST: That's right. Hopefully not. Spring and summer are coming.
MR. BURNS: Thought I'd throw it out.

MR. FROST: I'm done with winter.
MR. BURNS: That was for the "Game of Thrones" fans in the audience.
BY MR. BURNS:
Q Going back to page 1 of your report.
In that subparagraph C, you say based on your "reviews of the geology associated with the applicable mines, and the pressure and temperature histories recorded by the rocks, any amphibole found in Johnson's Baby Powder and Shower to Shower derived from the Fontane, southern Vermont, and Guangxi talc mines would likely be incidental actinolite or tremolite cleavage fragments from non-asbestiform amphiboles, most likely derived from the margins (blackwall zones) of the talc deposits."
Is that correct?
A Yes.
Q Okay. What do you mean by "incidental actinolite"?
A Well, that principally, except right along the -- the margins of the blackwall, you wouldn't expect actinolite to be present in the main body of talc ore, because the bulk composition isn't really appropriate for that.

And tremolite, also you wouldn't expect in great volumes in the talc itself, and that's because calcium is an essential element in these minerals.
And again, the chemistry that's reported for the -- the Ludlow and Dover bodies, which are our best proxy for the ultramafic protoliths, the mantle rocks that we started with, really low calcium levels, so -- whereas the metasedimentary and metavolcanic wall rocks are -- are more calcium rich, more iron rich. And so, you know, that's where the blackwall -- the actinolite in part -- by definition is part of the blackwall, these actinolite zones.
So, I guess "incidental" would mean that some accidental incorporation of -- of the blackwall.
Q Meaning that the mining encompassed part or all of that -- of one piece of the blackwall.
A Yeah. I mean, I don't -- again, I don't know. Basically, it's like I can't come up with a petrologic argument to say those should be present in any abundance in the -- the talc that was the desired mining product. So it's most likely coming from the margins. But...

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Q Okay. Is actinolite a regulated form of asbestos?
MR. FROST: Objection to form.
THE WITNESS: Asbestiform actinolite is one of the regulated minerals, yes.
BY MR. BURNS:
Q And you mentioned specifically tremolite cleavage fragments; is that correct?
A Well, actinolite or tremolite cleavage fragments.
Q Okay. So both -- both modified --
A Yeah, meaning that this actinolite, the tremolite is not -- asbestiform did not grow in that primary growth habit, and rather, could be ablated or acicular or prismatic tremolite that -- I guess then if it's -- somehow in the talc undergoes, you know, the beneficiation process, so crushing and grinding and breakdown into cleavage fragments.
Q So is it your testimony then that there would be no asbestiform actinolite or tremolite in the talc?
A That's -- yes, that's my testimony.
Q Okay. Let's turn to page 11. And to Figure 6.

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So Figure 6 is a "Pressure-temperature diagram modified from Winter (2001), showing in gray the general boundaries of the different metamorphic facies (for example, greenschist facies) that represent conditions under which certain combinations of minerals (i.e., equilibrium assemblages) are stable as a function of a rock's bulk composition."
Is that right?
A Yes.
Q How was this modified from Winter?
A I added in -- I believe the reaction curve for chrysotile and lizardite maximum stability, and that was taken from Evans, 2004.
Q And that was the tremolite?
A That was the chrysotile --
Q Chrysotile. Sorry.
A -- and lizardite maximum stability, the brown dashed curve at around 300 degrees C.
Q So Evans, 2004?
A Yes.
Q Okay.
A And then I also added the -- the green roughly oval-shaped region that was meant to encompass the -- the general range of pressure and

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temperature conditions under which the talc ores formed.
Q In all of the Fontane, southern Vermont and Guangxi talc ores; is that right?
A Yeah. In general, there's some overlap there. Guangxi would be more firmly in the greenschist boundary; Vermont would be more in the epidote-amphibolite facies, with the Fontane as well.
Q Okay. So there's a note in your description of Figure 6 that: "Conditions favoring asbestos formation are generally associated with low-temperature and/or low-pressure conditions," and then you describe the zeolite, prehnite, prehnite-pumpellyite --
A Yeah, prehnite-pumpellyite.
Q Pumpellyite. Thank you.
-- and hornfels facies, right?
A Yes.
Q Okay. And just so we are all on the same page and we can look at the same thing for a second, I'm going to circle each of those areas.
See if I get them all correctly. I've tried to circle here the areas where conditions favor asbestos formation. Did I capture them all?

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A Yeah. I mean, in terms of low temperature, that could extend up to the -- the blueschist facies.
Q Mm-hmm.
A I mean, the key thing is there, again, low-temperature deformation tends to be more brittle and -- and allow the -- the ability for fractures to open, which is one of the -- the most common site for asbestos to -- to form.
Q Okay. Now, is it --
MR. FROST: Just a -- I'm just going to object to some of the circles. It seems different than what's listed at the bottom of Figure 6.
MR. BURNS: And if it is, let me know.
THE WITNESS: The hornfels, I was just speaking generally to the -- the high temperature, low -- low pressure. So...
BY MR. BURNS:
Q So would it include the albite-epidote-hornfels, which looks to be low pressure, relatively low temperature or --
A Yeah. I don't have an issue with what you circled. I mean --
MR. FROST: I just wanted the record to be clear.

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MR. BURNS: Mr. Frost -- Mr. Frost does, but --
MR. FROST: But I just wanted to make sure the record was clear.
MR. BURNS: All right. Fair enough.
BY MR. BURNS:
Q So you mention -- mentioned fractures. And I believe you said that fractures are one of the conditions where asbestos can form. Is that correct, or something along those lines?
A Yes, most -- most commonly as those cross fibers or slip fibers.
Q Mm-hmm. So, speaking generally and recognizing -- well, strike that.
Not having your background and expertise, I have some general questions about this.
So it appears from this figure that the talc in the Fontane and Vermont and Guangxi ores, in your view, based on its -- based on I guess that regional petrology and circumstances there, would have formed at about, what, 500 degrees Celsius and 0.6 GPA pressure; is that right?
A That's a good ballpark.
Q Okay. And the conditions for the

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creation of asbestos sort of surround that area, but obviously at different pressures and different temperatures.
Would minor variations in temperature or in pressure, had they occurred, could those have resulted in asbestos materials coming into the same ores?
A I don't --
MR. FROST: Object to form.
THE WITNESS: I don't believe so.
BY MR. BURNS:
Q And why?
A Well, again, when you're at the low temperature end and rocks are -- would deform brittlely, again that's generally when fractures could open. And because of the primary growth habit of asbestiform fibers, they're basically growing into -- into void spaces. So that's a precondition, coupled with fluids that are saturated and the chemical components from which the asbestiform minerals would grow.
When you look at the -- when I say -- or generally the hornfels conditions here, yeah, you have higher temperatures, but you also have very low pressures. And so rock strength increases

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with depth because of the weight of the overlying column of rocks, and so if you're at low pressures, the rocks are a bit -- a bit weaker, but you don't have that pressure that basically fights against voids opening.
So the rocks either have to be low temperature and brittle because of that or shallow in the earth's crust to basically not have enough weight down on you to -- to keep voids from opening.
You know, whereas the -- the conditions of metamorphism for the formation of talc, much higher temperatures and, you know, 20 kilometers deep. That's pretty deep in the continental crust. And we know from people who have studied the -- again, the structures that these were undergoing ductile deformation at the time.
So it's just those geologic conditions aren't -- that's why I say they aren't favorable, aren't -- aren't amenable.
Q At the same time, right? Is that the issue?
MR. FROST: Objection.
BY MR. BURNS:
Q It would be difficult to have the same

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conditions exist at the same time for the creation of both the asbestos materials and the talc ores. Is that right?
MR. FROST: Object to the form.
THE WITNESS: Yeah, I mean, I would say that, yes, at the time the talc was forming, the conditions were not appropriate.
BY MR. BURNS:
Q Okay. Now -- but I believe we've described circumstances where -- I'm thinking of Italy where you said the talc may have formed earlier in the continent's subduction zone, but have survived the subduction.
Is it possible that -- are there circumstances where asbestos could form at a later time and under favorable circumstances where the talc would remain solid, because it's a stable mineral, but a fracture, for example, could lead to the incorporation of asbestiform materials?
MR. FROST: Objection to form.
THE WITNESS: Well, I mean, I suppose we could devise a hypothetical situation where the conditions were all ripe for this to happen, but there's no evidence that that's the case.
As I said, all asbestos in Vermont,

everybody has written about it, there's no disagreement that that occurred, you know, 80 million years prior to the formation of the talc, give or take a few million years.

And the conditions that postdated the formation of the Italian talc in the Fontane mine were way up here (indicating). So, I mean, maybe similar in temperature, but much, much higher -- higher pressures. Yeah, they're back at the -- the surface today, but, you know, I think -- again, when asbestos forms, it's -- it's regional conditions that allow that to occur, and so we'd have other -- I would expect to see that documented throughout the -- the geology. And I just -- you know, I don't see any evidence for it.

BY MR. BURNS:

Q Turning to the Vermont example where the asbestos formed before the talc, are fractures again a potential explanation for migration of the asbestos --

MR. FROST: Objection to form.

BY MR. BURNS:

Q -- subsequently?

A I've never heard of migration of asbestos, so I don't know --

Q Well, I didn't really mean migration. I mean the filling in of those -- those fractures with the asbestiform materials.

A I mean, dominantly in Vermont where asbestos is documented, it's says cross and slip fibers.

Q And what do you mean by that?

A That basically as these fractures were opening, they're apparently, you know, filled with fluid at the same time that became saturated in the chemical component, so the chrysotile chemical formula basically, that those minerals or, you know, fibrils nucleated on walls of -- of the fractures, and depending on whether they opened like that or like that (demonstrating), in this case they appear to continue to grow as the fracture continues to open. So it's -- the nucleate on either side and -- or there are some veins where things nucleate in the middle initially, and then grow outward as well.

But in any case, the fibrils would be growing as the fracture is opening. So cross fibers would be perpendicular to the fracture walls. Slip fibers would be one of those fractures where there's, you know, some offset

along that, and that's when you would get the fibrils basically at an angle to the -- to the fracture walls connecting on either side.

Q Okay. And you say that is the most common means by which the asbestos occurs in Vermont?

A (The witness nods.)

Q But not with respect to the J&J mines.

MR. FROST: Objection to form.

THE WITNESS: I'm -- I don't know what you mean by that. Sorry.

BY MR. BURNS:

Q Well, meaning because you haven't seen any evidence of asbestos in the J&J mines, what you're describing there would not be true of those mines?

A Yeah.

MR. FROST: Objection to form again.

BY MR. BURNS:

Q Given the geologic -- given the geology -- the local geology of the J&J mines, would that process have been possible?

A I mean, again, we could devise a hypothetical situation that might satisfy those conditions, but I --

Q I realize you haven't seen it, but would -- would it be possible?

MR. FROST: Objection to form. Inappropriate hypothetical.

THE WITNESS: Yeah, I'm sorry, I don't know how to -- you know, lots of things are possible, but many things don't happen. So I can't -- I don't -- I can't comfortably answer that without having all of the variables sort of outlined for me and --

BY MR. BURNS:

Q Well, I certainly understand that, but really I -- we're talking about a pretty small set of variables, the ones you described as relatively common in Vermont in terms of the formation of asbestos materials.

And what I'm saying is, given the regional geology that's present in the J&J mines, is it possible -- not probable, not, you know, highly possible -- but is it possible that that process of the creation of asbestos may -- may have occurred in a similar fashion in those J&J mines?

MR. FROST: Same objection to form and inappropriate hypothetical.

THE WITNESS: Yeah, like I said, we could devise a -- a scheme presumably in which that could occur, but it's -- while it might be possible in some parallel universe, I -- I just -- it's not probable, and I just don't see any evidence for it having occurred here.
BY MR. BURNS:
Q Well, what would constitute evidence for you in that context?
MR. FROST: Objection to form.
THE WITNESS: Well, I would imagine that in that belt of rocks, people would record fractures filling with asbestos, more generally, in the literature. Because, again, people have been looking at these rocks for over a hundred years. People are certainly interested and concerned about asbestos.
So, had -- you know, it would be documented in some of these, you know, Vermont state reports, the USGS reports in the peer-reviewed literature around the Chester dome, and it's just -- it's not in anybody's data and observations in the -- in the field.
BY MR. BURNS:
Q Well, what if it -- and this -- just

throwing this out there, what if -- what if it was documented in a core log or observations by the mining company at, say, the Argonaut mine, would you consider that evidence?
MR. FROST: Objection.
BY MR. BURNS:
Q That would at least merit additional testing?
MR. FROST: Objection to form.
THE WITNESS: Well, I mean, you know, if you've got evidence where people have -- I mean, where I can understand the methodology that was used and see the data and observations -- I don't want to take some random person who I don't know their qualifications or what they're describing.
You know, so I'd be happy to -- if you've got something you want me to look at that -- that presents that, to consider it, sure.
BY MR. BURNS:
Q Okay. But you weren't presented any such evidence when you were doing your report.
MR. FROST: Objection to form.
BY MR. BURNS:
Q Correct?
MR. FROST: Supposes there's evidence.

THE WITNESS: Yeah, and I did not find any, because, again, the vast majority of what I looked at was my own research.
MR. BURNS: Okay.
THE WITNESS: Can I take a quick break?
MR. BURNS: Oh, of course, sure.
THE WITNESS: I've been drinking a lot of water and tea and --
MR. FROST: Yeah, I was going to say, actually, I could use the restroom.
THE VIDEOGRAPHER: Going off the record at 4:26.
(Recess.)
THE VIDEOGRAPHER: We're back on the record at 4:57 p.m.
BY MR. BURNS:
Q Welcome back, Dr. Webb.
So, Dr. Webb, we were talking about when last we left off, evidence -- evidence for asbestos in talc in the J&J mines in Vermont, specifically.
MR. BURNS: Let's go ahead and mark this, Amanda.
(Webb Exhibit No. 12 was marked for identification.)

BY MR. BURNS:
Q All right. I'm going to hand you what we've marked as Exhibit 12.
And just let me know when you are ready, if you want to take a second to look it over.
A Okay. (Peruses document.)
Okay.
Q All right. Dr. Webb, have you seen this -- well, let me start.
Exhibit No. 12 is a document bearing the Bates labels IMERYS 219720-722. It appears to be dated March 25th, 1992. Title appears to be "Cyprus Ore Reserves - Arsenic & Tremolite."
Did I pronounce that -- or did I read that correctly?
A "Cyprus Ore Reserves - Arsenic & Tremolite," yes.
Q Okay. Great.
Have you seen this document before?
A I have not.
Q Okay. This -- and have you had a chance to read it?
A I did, yes.
Q Okay. And is it fair to say that this document contains some discussion about the

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presence of asbestos materials in talc deposits in Vermont?
A It mentions fibrous amphiboles.
Q Including tremolite; is that right?
A Yes.
Q Okay. Is this the type of evidence that would give you some concern if you had been presented it when conducting your analysis?
A Not really, because fibrous is a -- a general term for maybe an elongate or long aspect ratio, but it's imprecise, and so it doesn't necessarily indicate asbestos.
Q Fibrous tremolite?
A Yes.
Q It doesn't indicate asbestos to you?
A No.
Q Okay. Why is that?
A Again, because "fibrous" is used by different people in different ways, and I've seen many instances in the literature where it's used for -- synonymously with like acicular. I mean, I've used the terms "fibrous" in my work when I'm talking about working with fault zones and -- and quartz fibers, for example. But, again, it's because they're crystals with long aspect ratios,

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and it's -- it's not synonymous, not -- you can't take this to -- to indicate asbestiform tremolite.
Q Have you -- what would you -- what else would you need to take it to mean asbestiform tremolite?
A Well, some detailed description about the habit of the minerals that is consistent with the definition of "asbestiform."
Q Well, so I'll direct you on page 2 to the fourth paragraph down.
It says: "Cyprus claims that there are no fibres in their cosmetic talc products, and they work rigorously to ensure this. However, a recent paper published by Rutgers University worker, Alice Blount, suggests the presence of fibre in several cosmetic talcs, some of which might have been from Cyprus West Windsor material, which is a source of great concern to Cyprus management, and potentially to their principal customer, Johnson & Johnson."
Why would Cyprus be concerned about fibrous asbestiform materials, including references to fibrous tremolite, if it were not asbestos?
MR. FROST: Objection to form.

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THE WITNESS: Well, again, I mean, it's the use of the -- fiber's an imprecise term. I mean, obviously they don't want asbestos in -- in their product, so -- but, again, I don't -- I don't see anything here that -- that indicates this term is -- is really -- equates to asbestiform. So...
BY MR. BURNS:
Q Well, the next paragraph down says: "Vermont talcs are derived from altered serpentine - a natural host for asbestiform minerals. There is certainly visible tremolite and actinolite in specific zones of the Vermont deposits - fibrous tremolite was identified by the writer in exposures and cores at the East Argonaut and Black Bear mines. Cyprus staff report past tremolite from the Hammondsville and Clifton deposits."
Did I read that correctly?
A Sorry. Where was --
Q That's the fifth paragraph down, page 2.
A Yeah. So, I mean, you know, in general, tremolite, I'm not concerned about that. Tremolite means to me -- again, without -- unless it's really described in detail, that's consistent with the asbestiform habit, which again is a

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primary growth habit.
You know, I'm not shocked that there's tremolite here. I'm not shocked that there's maybe acicular tremolite or, you know, tremolite that someone might describe, depending on how they used the term "fiber," as -- as fibrous. But I can't -- I can't take anything in here and say, This leads me to believe that there's actually asbestos that's been identified.
Q Is asbestiform tremolite a regulated form of asbestos?
A Asbestiform tremolite is a regulated form, yes.
Q Are you able to discern from the terminology used in this memo -- are you -- strike that.
Are you able to exclude the possibility that the tremolite referenced in this memo is indeed asbestiform tremolite?
MR. FROST: Objection to form, calls for speculation.
THE WITNESS: Well, again, I mean, asbestos is so rare, and, again, takes these special conditions that --
I'm sorry, I lost the -- the question.

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BY MR. BURNS:
Q No problem. I simply asked, can you exclude the possibility that this is asbestiform tremolite that's referenced in the memo?
A Based on everything I have learned and reviewed and understand, yeah, I -- I just can't -- I can't read this and say that this convinces me of anything. I'd, again, need to see field photographs of what this worker saw or photomicrographs, the -- again, a real distinct description that is consistent with the asbestiform habit. And fibers, fibrous, just -- it could mean anything. It could mean a number of things.
Q So it's fair to say that reading this, you would need to see more?
A Yes.
Q Okay. Now, there's a reference in the sixth paragraph down. It says: "Tremolite in these deposits is encountered in the contact zones between the talc and the surrounding schist; in 'grey talcs' in the vicinity of the contacts; and associated with the chlorite/amphibole waste zones within the talc ores that are locally termed 'cinders.'"

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Do you see that?
A Yes.
Q Are you familiar with the term "cinders"?
A I've heard it. I mean, it's not a term that I throw around, but...
Q What is your understanding of what it describes in -- in layman's terms?
A Like I said, I've heard it, but it's not something I use, and so it's not something I feel prepared to define for you.
Q Have you ever investigated cinders in your -- in your work?
A No.
Q When -- were you to investigate -- strike that.
Were you to examine a sample of tremolite to determine whether it was asbestiform, what would you do?
MR. FROST: Objection to form. Outside of the scope of her expertise.
THE WITNESS: Well, I mean, I think it would start with the recognition of -- of fibrils, bundles of fibrils, and, I mean, you could recognize that in an outcrop if -- if you saw

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that. If you've seen, I mean, asbestos in a hand sample, which hopefully you've never held in your hands, I know, but we've got drawers in the rock collection at UVM -- I mean, asbestos is pretty apparent when you see it in -- in person at the macroscopic scale.
BY MR. BURNS:
Q Okay.
A Yeah.
Q And in the microscopic scale, what are you looking for? Is there a certain aspect ratio of the fibers that you're trying to determine?
MR. FROST: Same objection. Beyond the scope of her report and her expertise.
THE WITNESS: Yeah, I mean, there's no one specific aspect ratio. Again, you would -- if it were -- if it were broken down and you were looking at a loose pile of this -- well, again, in bulk, I think it would be clear because you would have long fibrils and bundles, and there would probably be some that might be curved and they might be quite long.
In -- under the microscope, I mean, you would be looking for the same thing, long -- long aspect ratios, but, again, nothing specific

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because it might vary in -- in the population you're looking at.
BY MR. BURNS:
Q Would a 5-to-1 ratio suffice?
MR. FROST: Same objection.
THE WITNESS: No.
BY MR. BURNS:
Q No?
A (Witness shakes head.)
Q Are you aware that that's the ratio specified by the National Institute of Occupational Safety and Health?
MR. FROST: Objection to form. Misstates document.
THE WITNESS: I -- I know that there are 5-to-1 and 3-to-1, depending on the -- my -- the source of the -- the counting criteria, that there are small-aspect-ratio cutoffs for like that. But, again, you know, that's in cases -- those ratios were developed for cases when there's abatement of known asbestos at hand.
So, you know, I would say that I regularly run into minerals that would meet that criteria, 3-to-1 or 5-to-1, and they're -- you know, they can be quite -- well, not that large,

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but, you know -- so, again, scale matters as well.
But, yeah, I don't think that's a -- an accurate cutoff or criterion for -- for issues outside of abatement.
MR. BURNS: Let's mark this one, Amanda.
BY MR. BURNS:
Q We'll mark this as Exhibit No. 13, Dr. Webb.
(Webb Exhibit No. 13 was marked for identification.)
THE WITNESS: (Peruses document.) Okay.
BY MR. BURNS:
Q All right, Dr. Webb. Exhibit 13 is a document with Bates label IMERYS 28 -- 238270 through 238277, and it's titled "Interoffice Correspondence," "Subject: Hamm Mine Core Drilling."
The second paragraph, Dr. Webb, contains the following sentence: "Fibrous amphiboles (actinolite) were observed only within chloritized mafic dikes, extending, in places, a couple of inches into the contacting talc ore."
Did I read that correctly?
A Yes.

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Q Is this the type of statement that would cause you to want to seek more information?
A Not necessarily, because, again, fibrous amphiboles, in general, 99 percent of the time will not necessarily refer to asbestiform actinolite, and -- I mean, I've seen images where, yeah, most of these amphiboles in the region have these long aspect ratios, but, again, they do not meet the criterion of -- of the asbestiform habit.
Q And what criterion are you speaking of in that context?
A Again, well, primary growth habit of fibrils in -- generally in bundles that have long aspect ratios but high flexibility, relatively defect-free surfaces which impact or -- are part of what leads to their chemical resistance.
So, again, without photomicrographs or photos that really give the details of what is meant by fibrous, there's no way to extrapolate from this the presence of asbestos.
Q But given the potential risk and the -- and the fact that you can't exclude the possibility of asbestos, wouldn't you want to seek additional information?
MR. FROST: Objection to form.

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THE WITNESS: No, because, I mean, up and down Vermont, near talc, away from talc, people describe a lot of fibrous amphiboles, and, you know, virtually in all cases they refer to -- this term is used for an acicular habit that is distinctly different from asbestiform.
So, I mean, nothing I read here is surprising to me. It -- it doesn't raise the questions that, you know -- again, in the absence of detailed descriptions, there's --
BY MR. BURNS:
Q And that's even though up and down Vermont, the presence of confirmed asbestos has occurred?
MR. FROST: Objection to form.
THE WITNESS: Virtually all of that is chrysotile, and not amphiboles, and, yeah, there's a lot of amphibole in -- in the Green Mountains, and so -- I mean, long aspect ratio amphiboles are -- are garden variety amphiboles in our state.
MR. BURNS: Let's mark this one -- 14?
(Webb Exhibit No. 14 was marked for identification.)
THE WITNESS: Does anybody have a magnifying glass handy? Shall I do --

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BY MR. BURNS:
Q And just to help you out, I'm going to point you to -- you're welcome to look at the whole thing -- I'm going to focus on the back side of page 2.
A So, yeah, the page where I asked for --
Q The page where you needed a magnifying glass.
A I do have reading glasses in my --
Q Well, let's see, do we have a clean copy here? I can probably blow it up a little bit here.
MR. FROST: You can take this one. It's clean.
MR. BURNS: All right.
MR. FROST: Is that -- can you see that better, Laura?
MR. BURNS: Not yet.
MR. FROST: He's going to try to zoom in on it.
THE WITNESS: I mean, actually, can I get my glasses, and --
MR. BURNS: Sure, absolutely.
THE VIDEOGRAPHER: Going off the record at 5:22 p.m.

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(Pause.)
THE VIDEOGRAPHER: We're back on the record at 5:24 p.m.
BY MR. BURNS:
Q Okay, Dr. Webb, you have Exhibit 14 in your hand, which bears Bates label IMERYS 436951 through IMERYS 436971.
Just one question about Exhibit 13, the preceding exhibit, just a quick question. Had you seen that exhibit before?
A No.
Q Okay. So same question with respect to Exhibit 14 to start, is this a document you've seen before?
A No.
Q Okay. Let's focus on the fourth page in the documents, IMERYS 436954.
A Sorry, is the first -- is this page 1?
Q Yes.
A Oh, okay. So it's the back of the second sheet. Yeah, okay.
Q That's right.
A I'm making sure it's what I actually looked at.
Q No problem. And I've put it up on the

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ELMO, just so we can have a little bit better view of it. I don't know if that's better for you or --
A I'll look at where you're pointing at, and then I'll confer with this too.
Q Okay. These appear to be and are titled "Ore Characterization Summary Sheets." Do you agree with that?
A What was the first word you said, "before"?
Q "Ore Characterization Summary Sheets."
A Yes, this says "Ore Characterization Summary Sheets," yes.
Q Okay. And there appear to be two of these summary sheets side by side dated September '92, specifying ore types and associated materials.
A Yes.
Q And you see in both the presence of actinolite and serpentine is indicated.
A Yeah.
Q Okay. And they are also -- the actinolite and -- the actinolite is noted as a detrimental mineral below each notation; is that right?

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A Yes.
Q Would these notations cause you to want to inquire more as to the nature of these test findings or core samples and the constituency of the minerals?
MR. FROST: Objection to form.
THE WITNESS: Yeah, I mean, again, the presence of actinolite around the ore bodies is, you know, not a shocker whatsoever. I mean, so it doesn't surprise me.
You know, in terms of "detrimental minerals," I don't know what they mean. Obviously these are things that they don't necessarily want in the -- I mean, I don't want to rub actinolite on my face, asbestiform or non-asbestiform, but --
BY MR. BURNS:
Q Are those questions you would want to ask the author?
MR. FROST: Objection to form.
THE WITNESS: No, again, because I wouldn't be surprised about the -- the presence of actinolite generally that -- you know, I'd see this and move on, and again try and find -- well, like in the materials that I looked at, some --

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some indication, some description that would equate this actinolite to asbestiform actinolite.
BY MR. BURNS:
Q Well, if you were blindfolded and the person who obtained and tested the sample told you that it contained actinolite, would you want to rub that on your face?
MR. FROST: Objection to form.
THE WITNESS: It would hurt. I mean, it would be gritty.
BY MR. BURNS:
Q If it was asbestiform, it may be even worse.
MR. FROST: Objection to form.
THE WITNESS: Well, yeah -- but, yeah, I mean, again, you know, actinolite is no surprise. I talk about actinolite in my -- in my report. In the absence of clearcut asbestiform habit --
BY MR. BURNS:
Q You're just not interested in knowing more?
MR. FROST: Objection to form.
THE WITNESS: I mean, well -- yeah, I mean, I -- I feel like I'm not surprised to see actinolite show up occasionally in the tests, and

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that is not a surprise. It's known. I don't know what else to say. It's --
BY MR. BURNS:
Q Have you drawn any -- are you prepared to offer any opinions with respect to the presence or absence of arsenic in the talc in the J&J mines?
A I mean, I -- I'm familiar with some of the -- the literature. It wasn't something that I focused or, you know --
Q Or you were asked to do.
A -- or opined about in my report. So, I know some things, but I didn't prepare in depth on that topic for this deposition.
Q Nor have you offered an opinion on it?
A No.
Q Do you plan to offer an opinion on it?
MR. FROST: Objection to form.
THE WITNESS: Not really, but I guess it depends on what you ask me, the nature of the questions, if there are further questions on that.
BY MR. BURNS:
Q What about any other heavy metals in the J&J talc --
MR. FROST: Objection.

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BY MR. BURNS:
Q -- are you going to offer any opinion on those?
MR. FROST: Objection to form. Assumes there's any metals in the J&J talc.
THE WITNESS: Again, I -- I have some general knowledge, but it's not literature that I reviewed or summarized for here. So I don't feel prepared to -- as we sit here today, to opine on that.
BY MR. BURNS:
Q And just so I can close that loop, any opinion as to the presence or absence of nickel?
MR. FROST: Same objections.
THE WITNESS: I mean, I would say presence, yes. At what levels is where the devil in the details is, so -- and I can't quote you parts per million or parts per billion here, but --
BY MR. BURNS:
Q Same question with respect to cobalt?
A Same answer.
Q Chromium?
A Similar answer, yeah, and, again, I'm --
Q But you're not prepared to offer an

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opinion as to the presence or absence of any of those minerals?
A Well, again, they're -- they're trace elements that I know have been documented, but, you know, again, I don't have it in my head what -- what those concentrations are or the details of the distribution. So I'm not -- I'm not ready today to -- to comment on that for you.
Q And you haven't been asked to.
A No, I have not been asked to, no.
Q Okay. If you'd go back to Exhibit 1, your report, Dr. Webb.
And I realize the level of detail on page 17 in -- in Figure 9 makes this difficult.
First of all, did the mineral codes or rock codes vary across maps, or can they vary?
MR. FROST: Objection to form.
THE WITNESS: Each of the different colored or patterned units here is a different -- is a different rock unit. So, yes, there's a distribution of different rock types here in this --
BY MR. BURNS:
Q Well, by that I mean -- let's see, this map was taken from --

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A It's Ratcliffe, et al., 2011.
Q 2011. Okay. Which was a GS -- USGS map, right?
A (The witness nods.)
Q And have you cited or described any non-USGS maps in your report?
A Well, I mean -- well, Karabinos -- not a specific map -- well, actually, there are -- in Karabinos, et al., 2010, I talk about the isograds. Again, the -- the lines that you would draw on the map that delineate boundaries between rocks that have experienced the same pressure temperature conditions during a metamorphic event.
Q Okay. And what I'm really getting at are -- is not necessarily the separation into different codes, but the codes themselves that are used for rocks that are relevant to your analysis. Can those vary across maps, meaning between the USGS maps and the other map you just described?
A Oh, they might.
MR. FROST: Objection to form.
BY MR. BURNS:
Q Do you recall offhand the specific rock codes that you viewed as relevant to your analysis in this particular case?

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A I believe the -- I'd have to look at the -- the map -- the map index to really confirm, but I believe that the ultramafics here are the CZU, and that, in general -- I mean, the -- the country rocks that host those bodies are -- that's the Mooretown information, but the -- O something. I -- yeah, sorry, I don't have the code memorized.

Q Okay. Are you familiar with any reports of mass fibers, mass asbestos fibers in Vermont talc deposits?

A No.

Q Are mass fibers relatively rare?

A Yes.

Q Where do they typically occur?

A Well, I know they've been documented at Belvidere Mountain. And also out in California in -- I'm not going to be able to remember the name of the -- of the body. But it's, yeah, in limited instances and much rarer occurrences than the cross and slip fiber occurrences.

Q Okay.

MR. BURNS: We have a couple of documents that we had pulled out that we need to figure out what to do with. You want to mark these individually or wait till we mark the --

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MS. O'DELL: Let's mark them individually.

MR. BURNS: Okay. That may make -- let's go off the record for a second.

THE VIDEOGRAPHER: Going off the record at 5:35 p.m.

(Recess.)

THE VIDEOGRAPHER: We're back on the record at 5:43 p.m.

BY MR. BURNS:

Q Hello again, Dr. Webb.

MR. BURNS: So, first of all, a bit of colloquy between counsel here. Defense counsel was kind enough this morning to bring in two boxes, which I believe were identical, of documents that defense counsel had put together that constitute what they believe to be, I think, the vast majority of your reliance materials with maybe the exception of Winter.

MR. FROST: I think that's the only one we found was missing thus far.

MR. BURNS: Thus far. So we have agreed to simply mark one of the boxes as Exhibit 15, with the stipulation that the box and its materials were gathered and prepared by counsel

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and not by Dr. Webb, although they hopefully approximate her reliance materials.

MR. FROST: Yep, that's fair, and that -- that's a fair statement of the agreement we reached.

MR. BURNS: All right. Great. Thanks, Mr. Frost.

BY MR. BURNS:

Q So we will mark that box Exhibit 15. There are a couple of documents, Dr. Webb, that we're just trying to figure out what they are, frankly, and we'll mark those as 15A and 15B.

(Webb Exhibit Nos. 15, 15A and 15B were marked for identification.)

BY MR. BURNS:

Q And I'll hand you 15A first.

There's 15B. B as in boy.

A I would want to confirm this, but my first impression is, is that this is from the spreadsheet that is part of Van Gosen 2006.

Q And that's referring to Exhibit 15A, is it not?

A Yes. 15A, yes.

So I believe, you know, if you go to the site, the USGS site from which you can download

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the map that I talked about that plots presumable asbestos localities in Vermont, there are some supporting documents, and in those, yeah, was this list -- I mean, it was for all of New England, but this is the sheet that's specific to Vermont, and it gives the latitude, longitude. And then this is the list of references that I said that I tried to dig into on my own to confirm those occurrences.

Q Okay. So just to be clear, 15A is not a document that you believe you prepared; is that right?

A Oh, yeah. No, I didn't prepare this. I think we could go and download the Excel file off the USGS website, and this is what would be in that.

Q I see.

MR. BURNS: And you can let us know with an errata, I would assume, if that's not -- not the case.

MR. FROST: Yeah, we'll confirm that.

MR. BURNS: Okay.

THE WITNESS: And I'm not sure, because when I went into the references, I went into the list that was specific to Vermont that's shown

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here in 15A.
My guess is that this is the -- the list of references that accompanied the -- the map more directly. So this would include -- again, this particular report was asbestos in New England or the northeastern United States, so he had these spreadsheets specific to each state. And then I think this is the -- a compilation of all these for -- for all of the sites that -- but, again, I -- we'd have to -- we should be able to download this from that same website, the USGS site.
BY MR. BURNS:
Q Thank you, Dr. Webb.
MR. BURNS: And I guess we'll just confirm that.
MR. FROST: Yes. Same thing, if we confirm something different, we'll mark it in the errata sheet.
MR. BURNS: Okay. Thank you.
So do we have a standalone one like this?
MS. O'DELL: No, that's all we have.
MR. BURNS: Okay. Let's make sure we've got -- this one is marked, so we probably want to make sure that there's a clean version in the

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actual Exhibit 15 box.
MR. FROST: What document is this, Leigh?
MR. BURNS: This is the English translation.
MR. FROST: Yes, that's definitely not in the box.
MR. BURNS: Oh, it's not?
MS. O'DELL: I found it in the box.
MR. FROST: Oh, you did find it in the box? Oh, okay.
MS. O'DELL: It was a few tabs after --
MR. FROST: I see. You had -- yeah, I did it too, Laura. Let's see if we can find a clean copy.
MR. BURNS: Thank you.
MR. FROST: You don't happen to know the number, do you?
MR. BURNS: Leigh.
(A discussion was held off the record.)
THE VIDEOGRAPHER: Going off the record at 5:48 p.m.
(A discussion was held off the record.)
THE VIDEOGRAPHER: Back on the record at 5:50 p.m.

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(Webb Exhibit No. 15C was marked for identification.)
BY MR. BURNS:
Q Okay. Dr. Webb, we have handed you Exhibit 15C, C as in Charlie.
Is this the English translation of the Chinese article that we were looking at earlier?
A I believe so, yes.
Q Okay. Now, in looking through this -- and this was an article on which you relied in rendering your opinions with respect to the Chinese mines; is that right?
A I did, yes.
Q Okay. Now, in terms of the orogen of the talc in those mines, is it fair to say that the -- that the orogen of the talc was in part tremolite existing in the region?
A I'm sorry, I don't -- I don't understand the question.
Q Sure.
Let me just turn you to page -- well, there's a page -- let's see.
A I'll work with you.
Q Four pages before the end.
A Okay. So this one with the --

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Q That's it, I think.
And perhaps I wasn't precise enough or didn't use the right terminology, but if we walk through this page, I think you'll see where I'm going.
So the article refers to the mother rock that is directly related to mineralization is dolomite marble. Do you see that?
A Yes.
Q And by "mother rock," that would be the rock that was changed ultimately to talc?
A Yeah, so in my report that's the protolith.
Q Okay. The protolith.
Now, it goes on to say: "This formation contains 19 percent magnesium oxide in this zone, so the requirement for generating the talc ore deposit cannot be completely satisfied, and magnesium oxide must be absorbed from the external surrounding rock to supplement, and the surrounding rock that satisfies this formation condition is spilite." Is that right?
A Yes.
Q It goes on to say: "In this zone, the content of MGO in spilite is 8.14 percent on

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average. Through rock-mineral determination and analysis, magnesium oxide is mainly concentrated in the tremolite, the content" -- parentheses, "the content of tremolite in spilite is 30 to 35 percent."
Is that correct?
A Yes.
Q Okay. So in this case, would the tremolite existing in the spilite also be considered a protolith to the talc?
A Well, it's part of the metasomatic process. So what he describes here is, again, that there is diffusion of chemicals, of elements across the rock boundaries. And what he said is that basically if you look at the mass balance, you can't just form the talc that's present solely by the chemistry of the -- the dolomite alone. So that there was diffusion of magnesium across the rock boundary from the -- the spilite into the dolomite.
So, no, I mean, the protolith is still the -- the carbonate rock, but the magnesium that's ultimately in the talc, some percentage of that diffused from the -- the spilite.
Q Which the source of that magnesium was

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the tremolite in the spilite, correct?
A Yeah, that was the -- the magnesium-bearing mineral in the spilite, yes.
Q Okay. And the tremolite -- content of the tremolite and spilite was 30 to 35 percent, correct?
A Yes, that's what it says.
Q Is it possible that -- excuse me -- is it possible that tremolite was not fully assimilated into the resulting talc such that tremolite remains in the talc ore?
MR. FROST: Objection to form, misstates document.
THE WITNESS: Such that tremolite -- what was the last part?
BY MR. BURNS:
Q Remains in the talc ore.
A I think you mean remains in the spilite?
Q Well, what I'm getting at is some percentage of the magnesium would have come from the -- from the talc or from the tremolite -- let me strike that.
Some percentage of the magnesium oxide would have come from the tremolite in the spilite, correct?

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A Yes.
Q And that magnesium -- would that magnesium oxide have been contributed from the tremolite to form the -- to form the talc by -- actually, strike that.
Why don't I just ask you this question: How would the tremolite contribute that magnesium oxide to the formation of the talc ore?
A There would be, I mean, a metamorphic reaction. So -- and, actually, I think he describes this in here. I'd have to again kind of look at this in -- in more detail, but -- but basically the tremolite is -- is reacting -- well, undergoing a chemical reaction where the magnesium is liberated, and so then you're going to have residual silicon dioxide and also calcium, and some of that calcium I believe is contributing to the formation of -- of carbonate, of calcite in this case.
So the tremolite that does break down is no longer there. The magnesium went into the talc, in the talc ore, and the residual calcium and silica probably formed quartz and calcite.
Q Okay. Is it possible that the remaining tremolite could have been interspersed with the

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talc ore?
A Yeah, I don't -- I don't think so. It seems that they describe -- the boundaries are still pretty -- pretty clear. So -- but again, you know, I wouldn't be surprised if there was a little bit of tremolite maybe in with the -- the talc, but that doesn't mean anything in -- you know.
Q Without further question.
A Yeah, I mean, you know, my -- the default would always be that it's prismatic tremolite or, again, maybe acicular tremolite or ablated tremolite, but this is not a recipe for making tremolite asbestos.
Q Why would that always be the default?
A Because asbestos is so rare. I mean, I've seen tremolite in a lot of rocks, but I've never seen tremolite asbestos in -- again, in my own studies, and that -- you know, and most people haven't. You know, there's basically -- what are the statistics I quoted in my report? That of the amphiboles present in rocks in the continental crust, less than 1 percent by volume, I think, are asbestiform.
And so, you know, it really takes

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special conditions, a special situation to create that, and what is described here is not --
Q What percent --
A -- anything that leads me to believe that this resulted in tremolite asbestos.
Q What percentage of the crust do amphiboles make up?
A They're the fifth most common mineral generally in the continental crust, and, I mean, it depends on where you are. I think, you know, it's maybe -- let me check because I wrote something about this. I don't want to misspeak.
So in the coterminous United States by area, 6 to -- 6 to 10 percent of the rock types exposed at the surface are amphibole bearing.
Q And so 1 percent of that 6 to 10 percent would be asbestiform?
A Or less than 1 percent by volume of -- of all amphiboles, yes.
Q That would still be a pretty significant volume of rock, though, would it not?
MR. FROST: Objection to form.
THE WITNESS: Yeah, but it -- again, it takes special conditions. So where asbestos is formed, it's well documented by multiple

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instances, and it -- you know, it's rare. I -- just, you know, I wouldn't -- I would never expect if someone says tremolite or actinolite that they mean actinolite or tremolite asbestos unless it's -- that is specified in -- in those words, asbestiform.
MR. BURNS: Can we just go off the record for a minute?
THE VIDEOGRAPHER: Going off the record at 6:00 p.m.
(Recess.)
THE VIDEOGRAPHER: We're back on the record at 6:07 p.m.
BY MR. BURNS:
Q Dr. Webb, I believe you testified that you had reviewed Drs. Cook and Krekeler's reports; is that correct?
A Yes.
Q Okay. Now, did you review all of the reliance materials that were listed in those reports?
A Well, for -- particularly for the petrology related piece that I was specifically interested in, I did look up some of their citations. I wouldn't say all of them necessarily

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or I was familiar with many, but --
Q Did you look up Robert Virta, 1985, Bureau of Mines?
A I have seen that.
Q Okay. Do you recall reading it?
A Yeah. Can -- actually, can we see the exact citation, because I just want to --
Q I think we could mark it. Right?
(Webb Exhibit No. 16 was marked for identification.)
MR. FROST: Are we on 17?
MS. KLEVORN: 16.
MR. BURNS: 16, yep.
MR. FROST: That's right, because you marked everything as A, B or C, right?
Thank you.
THE WITNESS: Uh, I -- I believe I have seen this, but, again, it really wasn't of -- of interest because it's from New York. So it didn't pertain directly to the petrology of -- of the mines of interest.
BY MR. BURNS:
Q Do you recall there being references to talc mines within this document?
A I really have to read it again, because,

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again, I didn't -- I didn't review it in preparation for today. I -- I don't believe it was on my reliance either.
Q Okay. So this had -- you don't recall this report having any impact on your opinions. Is that correct?
A Yeah, I mean -- again, I mean, the samples are specific to the Gouveneur mine in New York state. So -- no, it didn't -- it didn't feed into my -- the opinions I presented in my report.
Q Okay. What about Charles Ratte, 1982?
A Yes, I've seen that. The state geologist report?
Q Right, the state geologist of Vermont, correct?
A Yes.
Q Did you review that report before --
A I --
Q I'm sorry, go ahead.
A No.
Q Did you review that report prior to rendering your opinions?
A Yes.
Q And did it impact your opinions at all?
MR. BURNS: Let's go ahead and mark it.

THE WITNESS: I don't think it was a -- a key player. I think I saw some things in there that seemed inconsistent with other data, and -- but, again, the details I don't have in my head.

(Webb Exhibit No. 17 was marked for identification.)

BY MR. BURNS:

Q Is that the report you reviewed?

A Yes. I recognize this, yeah.

Q And we've marked that as Exhibit 17. Okay.

MR. BURNS: All right. We have no further questions.

MR. FROST: Okay.

CROSS-EXAMINATION

BY MR. FROST:

Q So, Laura, I apologize. Sitting next to you is just going to make this, you know, a little more awkward, but I'm going to ask you a couple of questions now.

MR. FROST: Do you have Demonstrative 2, as you used it and marked it?

THE WITNESS: I do.

BY MR. FROST:

Q You have -- you have Exhibit 2, I think.

A Oh, sorry.

Q It's Demonstrative 2.

A It shows you what I know about --

Q I'm going to hand you what was previously marked as Plaintiffs' Demonstrative 2.

MR. BURNS: Yeah, so we want to enter that into the record.

MR. FROST: That's fine. We can mark that -- maybe we could mark it as Plaintiffs' Demonstrative 2 --

MR. BURNS: Yeah. So all I was getting at, if you're going to mark a version, we should --

MR. FROST: I'm not going to touch it.

MR. BURNS: Okay.

MR. FROST: No, I'm not going to mark it up. I just wanted to give it to her.

MR. BURNS: Go ahead.

BY MR. FROST:

Q Do you remember this document from earlier today?

A I do, yes.

Q Okay. Does this demonstrative accurately reflect your qualifications, knowledge, training and experience to render an opinion in

this case?

A No, it doesn't.

Q What is the best and most complete statement of your opinions with the context necessary to understand them?

A Well, that would be my expert report.

Q And that's the document that was marked as Exhibit 1 today?

A I believe so.

Q And what is the best, most complete summary of your qualifications, knowledge, training and experience to render an opinion in this case?

A Well, that would be my curriculum vitae.

Q And do you recall going through and answering many of the questions -- or I guess all the questions that are in Demonstrative 2; is that correct?

A Sorry, in this document?

Q Yeah, you remember going through these?

A Yeah. Yes.

Q Do any of these questions and your answers to them affect your -- affect your ability to render an opinion here?

A No.

Q Okay. I'm going to reach over if you don't mind.

Here, sorry.

Well, I will just show you my copies for purposes of what we're doing here. Okay.

All right. Do you recall being shown earlier today various documents marked as Exhibit 12, Exhibit 13, and Exhibit 14?

A Yes.

Q Do you have those there?

A Yes.

Q Okay. Are any of these documents the type of documents that a petrologist would consider in undertaking a review of the geology and petrology of the geological formation?

A No.

MR. FROST: That's all the questions we have.

MR. BURNS: Okay. Just a couple follow-up.

REDIRECT EXAMINATION

BY MR. BURNS:

Q One, just so it's clear, why don't we mark as Exhibit 18 the --

A The demonstrative?

Q -- what I was calling Plaintiffs' Demonstrative 2, just so it's in the record.

A It's now buried in the stratigraphy pile.

MR. FROST: There it is.

(Webb Exhibit No. 18 was marked for identification.)

BY MR. BURNS:

Q All right. You can put that over there. And finally, Dr. Webb, thank you for your time today. I did want to mark off that we did cover your report and opinions on Plaintiffs' Demo 1.

MR. BURNS: All right. Thank you very much.

MR. FROST: Great. Thank you, Warren. Thank you, Leigh and Amanda.

THE VIDEOGRAPHER: This ends today's deposition.

We're going off the record at 6:14 p.m.

(Whereupon, the deposition of LAURA WEBB, Ph.D. was concluded at 6:14 p.m.)

CERTIFICATE OF CERTIFIED SHORTHAND REPORTER

The undersigned Certified Shorthand Reporter does hereby certify:

That the foregoing proceeding was taken before me at the time and place therein set forth, at which time the witness was duly sworn; That the testimony of the witness and all objections made at the time of the examination were recorded stenographically by me and were thereafter transcribed, said transcript being a true and correct copy of my shorthand notes thereof; That the dismantling of the original transcript will void the reporter's certificate.

In witness thereof, I have subscribed my name this date: March 30, 2019.

____

LESLIE A. TODD, CSR, RPR

Certificate No. 5129

(The foregoing certification of this transcript does not apply to any reproduction of the same by any means, unless under the direct control and/or supervision of the certifying reporter.)

INSTRUCTIONS TO WITNESS

Please read your deposition over carefully and make any necessary corrections. You should state the reason in the appropriate space on the errata sheet for any corrections that are made. After doing so, please sign the errata sheet and date it.

You are signing same subject to the changes you have noted on the errata sheet, which will be attached to your deposition. It is imperative that you return the original errata sheet to the deposing attorney within thirty (30) days of receipt of the deposition transcript by you. If you fail to do so, the deposition transcript may be deemed to be accurate and may be used in court.

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ACKNOWLEDGMENT OF DEPONENT

I,__________________________, do hereby certify that I have read the foregoing pages, and that the same is a correct transcription of the answers given by me to the questions therein propounded, except for the corrections or changes in form or substance, if any, noted in the attached Errata Sheet.

____

LAURA WEBB, Ph.D.   DATE

Subscribed and sworn to
before me this
______day of______________,20___.
My commission expires:______________
____
Notary Public

A

Exhibit G

REPORT OF ITALIAN MINE

SAMPLES

J. & J.

DEPARTMENT OF MINERAL EXPLOITATION

UNIVERSITY COLLEGE
CARDIFF

EXHIBIT 17
Poulton
Date: 3-18-19
MLG, CSR, RPR, CRR

EXHIBIT 10
WIT: Pooley
DATE: 2-1-18
C. Campbell, RDR CRR CSR #13921

This document represents the completion report of the Italian mine samples and other powders supplied by Johnson and Johnson, Cosham, Portsmouth, to the Department of Mineral Exploitation.

The persons involved in the examination of the material reported here were:

Mr. J. Lightfoot

Mr. G.A. Kingston

Dr. F.D. Pooley

REPORT OF INVESTIGATION OF ITALIAN MINE SAMPLES AND RELATED POWDERS

Introduction

Talc is hydrated magnesium silicate ($Mg_3Si_4O_{10}(OH)_2$) which can occur in a number of forms. In its compact form it is known as stealite or soapstone. The form normally employed for toilet purposes is soft and very friable in character. It is mined in many parts of the world including the U.S.A., Canada, France, Italy, Norway and India, as well as several other countries. It occurs in both a flaky and lath like form and the chief deposits occur in altered magnesia-rich calcareous rocks such as dolomite, marble, and magnesian limestone. The purest talc deposits occur in association with dolomite and marble. Talc also occurs in altered basic rocks such as serpentines and again as thin beds in mica schists. Commercial talcs contain a number of related mineral impurities. They may include antigorite (hydrated magnesium silicate) magnesite or members of the magnesite-chalybite series of carbonates, dolomite (calcium magnesium carbonate), tremolite and actinolite (calcium, iron magnesium silicates), chlorites (magnesium aluminium iron silicates) and other minor minerals such as the sulphides and spinels.

The hand specimens examined in this report were collected at the Italian mine and do not represent an average collection of specimens of material being produced at the mine. The specimens were collected with the intention of sampling those areas with obvious non talc mineral inclusions. Specimens were retained which showed differences in physical appearance, i.e. fibrous, flakey, massive and powdery in texture. Specimens of ore in which colour variation was observed were also collected. In general the colour of the talc ore varied from grey through white to a light green colour. Obvious inclusions in the talc ore itself were retained and a careful search at the various sample locations in the talc seam was performed for fibrous amphibole minerals.

Specimens of the hanging and footwall were also collected to assess their mineral content as these were likely sources of ore contamination, although the method of mining which consisted of hand filling methods precluded any gross contamination of the ore.

The hand specimens have been, where possible, prepared for examination by the optical microscope and both polished blocks and thin sections of material have been employed. Representative fractions of all hand specimens have been reduced to powder form and subjected to powder X-ray diffraction examination. The representative powdered samples also form the samples for morphological examination by the electron microscope.

The list of samples obtained from the Italian mine are given in Tables 1 and 2 and throughout this report the samples are referred to by the preceding code number for each specimen.

The objective of the examination has been mainly to establish the major minerals which occur in association with talc at the Italian mine. In particular to look at the association of these minerals with the talc and especially those minerals which are of the same family as the commercial asbestos minerals, i.e. the amphiboles and serpentines.

The objective of the optical examination has been to establish textural and mineral relationship and not to quantify the phases occurring in each hand specimen. X-ray work has been aimed at establishing the minerals observed by optical means and to produce reference patterns for future investigation together with computed data from pattern measurement.

Electron microscope work has been selective in nature and performed on the finer fraction of the powdered specimens. Its aim has been to describe the morphology of the particles produced by comminution of the hand specimens and to investigate any obvious structural information which might be of use in identification of individual mineral particles.

Representative data obtained from the various examinations are included in the following report.

TABLE 1

LIST OF ITALIAN MINE SAMPLES

Code No.	Description
I.1.	Talc from footwall contact
I.2.	Sorting pieces (with obvious colour differences)
I.3.	Coloured talc (green)
I.4.	Face 10 sample with obvious amphibole inclusion.
I.5.	General ore
I.6.	Suspected Quartz sample
I.7.	Mica schist specimen
I.8.	Massive talc
I.9.	Grey talc 1st face
I.10.	Granular talc sample
I.11.	Carbonate and talc
I.12.	Footwall sample? Amphibolite
I.13.	Inclusion showing passage into talc bottom transit.
I.14.	Inclusion in talc seam face 4, middle of seam.
I.15.	Talc footwall contact
I.16.	Inclusion from face 1.
I.17.	Footwall rock sample
I.18.	Face 3 carbonate/talc sample
I.19.	Tremolite/quartz/talc sample
I.20.	Amphibole sample from Gianna level 1212
I.21.	Inclusion from face 2.
I.22.	Carbonate/talc sample
I.23.	Black gneiss 2 ft below talc seam
I.24.	Talc next to carbonate face 2.
I.25.	Footwall limestone
I.26.	Talc inclusions
I.27.	Lithological inclusions face 1

Table 1 Continued

Code No.	Description
I.28.	Quartz/talc sample
I.29.	Sample 6 footwall
I.30.	Quartz/Carbonate/talc sample
I.31.	Black inclusion face 1
I.32.	Face 2 inclusion from base of talc
I.33.	Talc from lower left end of working
I.34.	Marble/tunnel wall
I.35.	Massive carbonate from rear end of working
I.36.	Grey talc specimen
I.37.	Carbonate in talc inclusion
I.38.	Pyrite/talc specimen
I.39.	5" - 0 pieces from crusher
I.40.	Platey talc
I.41.	Face 2, good specimen
I.42.	Face 1, coloured green (talc)
I.43.	Face 10, fibrous sample
I.44.	Face 1, pure talc?
I.45.	Face 1, good specimen
I.46.	Face 3, coloured specimen

TABLE 2

OTHER SPECIMENS EXAMINED

Code No.	Description
B1	Pure talc 1st face
B2	Greenish talc 1st face
B3	Talc 6 inches above footwall
B4	Talc from above inclusion
B5	Inclusion in talc
B6	Talc 2 ft above inclusion
B7	Section 2 ft above inclusion
B8	Pure talc 1st face
B9	Grey talc 1st face

Also examined

1) Batch shipments of ~~/////~~ talc

2) Old samples of British powders.

OPTICAL EXAMINATION OF SPECIMENS I1 - I46

Thin and polished sections were prepared of the specimens of wallrock and, where possible, the talc ore.

The minerals which formed a major constituent in at least one of the sections were quartz, muscovite, talc, chlorite, (var sheridanite), calcite, garnet, and tremolite; the latter only occurred as a major constituent in section I19. Phases which were always minor or accessory were microcline, plagioclase, biotite, pennine, epidote, clinozoisite, hornblende, actinolite (section I7), rutile, and opaque constituents pyrite, pyrrhotite, and chalcopyrite.

The identification of the minerals in the sections of these specimens was based on the optical characteristics of the minerals in transmitted and reflected light, both under plane polarised light (PPL) and crossed nicols (XN), combined with the results of the X-ray diffraction study of the crushed hand specimens. In some cases material was extracted from the sections and examined in R.I. liquids as in determining that the most common chlorite mineral in these specimens is a variety called sheridanite having a R.I. ω equivalent of 1.590 ± 0.005 and a birefringence of 0.012 - 0.014. Similarly much of the muscovite was nearly uniaxial with a R.I. of 1.600 corresponding to the variety phengite, an abnormally siliceous muscovite. In the case of talc its confident determination optically is difficult since its optical properties are identical to muscovite. However, it was found that the common "feathery" form of the talc combined with the invariable occurrence of minute transparent inclusions (suspected to be silica) in the talc producing a 'dusty' appearance in thin section and a greenish colour in hand specimen, enabled talc to be distinguished from muscovite. Talc also exhibited slightly higher order interference colours in general. Where talc was only an accessory mineral to muscovite, as in some of the wallrock samples, then it could not be distinguished with certainty.

In the following pages (no to) the Italian specimens are systematically described as regards their mineral composition and mode of intergrowth. Numerous photomicrographs taken under PPL and XN are provided with the description to mainly illustrate the rock textures which, it is hoped, will provide information useful in the comminution of particularly the talc ore samples, and also displays the non occurrence of asbestiform amphiboles in the talc ore.

Specimen I1

Specimen I1 consisted of several pieces of wallrock with one piece displaying the talc/footwall contact. One polished section was made of the talc/footwall contact and one thin section of the wallrock alone.

The wallrock is a schist which in thin section displayed a segregation of the main minerals into thin lenticular bands composed, as in Figure 1, of long tabular aggregates of intermixed muscovite (var. phengite) and chlorite (var sheridanite), and granular quartz exhibiting a polygonal grain boundary structure. Accessory rutile occurs as orientated inclusions in the chlorite and muscovite, and also opaque constituents which in polished section were identified as dominantly pyrite metacrysts with minor pyrrhotite. Some subhedral porphyroblasts of plagioclase also occur.

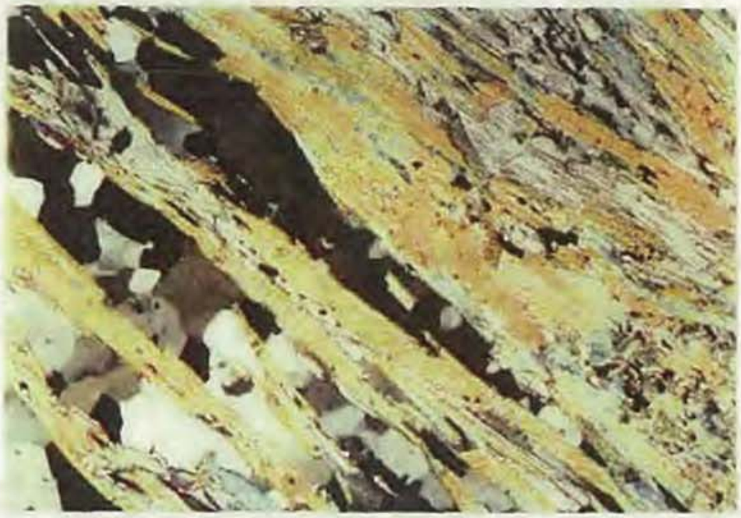


Fig. 1. Photomicrograph, X 40, of thin section of wallrock I1 under crossed nicols. A schist of quartz (granular white-black), muscovite (lamellar yellow-blue), and chlorite (lamellar white-blueish grey).

Specimen I3: 'coloured talc'

The minerals composing this specimen are major talc and chlorite (var sheridanite) with the talc content much greater than chlorite, together with accessory garnet, rutile, and an unidentifiable finely dispersed phase occurring as minute transparant inclusions along the cleavage planes and grain boundaries of the talc and imparting a dusty brown appearance to the talc in thin section and a greenish colour in hand specimen. The talc occurs as medium grained feathery aggregates which are in places 'dusty' and grade into 'clean' transparant aggregates which are free of any inclusions. It appears that some retrograde metamorphic process has caused the inclusions to be removed or incorporated into the talc structure since single talc crystals display both types. The

minor chlorite is dispersed in the talc matrix as small lenticular and globular fibrous aggregates. Rare garnet, possibly a member of the ugrandite series because of its anisotropy, occurs as subhedral porphyroblasts.

Fig. 2. Photomicrograph, X 24, of thin section of 'coloured talc' specimen I3 under crossed nicols. Dominantly talc (yellow-blue interference colours) showing murky brownish black patches due to presence of fine unidentifiable inclusions.

Specimen I5: general ore

A coarse aggregate of curving foliaceous and feathery crystals of talc displaying evidence of shearing and translation twinning. As in specimen I_3, dusty inclusions of a transparant mineral with a general prismatic habit occurs dispersed in the talc. As before, but to a lesser extent, the talc is cleansed of these inclusions along zones associated with deformation and translation twinning, and it appears that the inclusions have either been converted to talc (as in the conversion of tremolite to talc by low temperature CO_2 metasomatism) or incorporated into the talc structure as a result of retrograde deformation metamorphism. Rare small subhedral garnet porphyroblasts also occur.

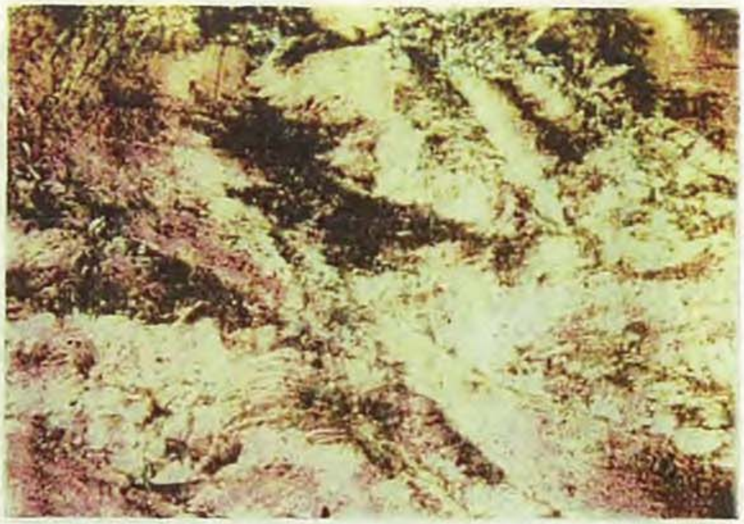


Fig. 3. Photomicrograph, x 24, of thin section of 'general ore' specimen I5 under crossed nicols showing the texture of the talc, and the 'murky' inclusion-rich talc compared to the clear inclusion-free talc.

Specimen I6

Specimen I6 consists of a very coarse aggregate of interlocking anhedral magnesite grains which exhibit strongly irregular and angular penetrating grain boundaries. The magnesite is characterised in thin section, Fig. 3a, by its marked change in relief and perfect rhombohedral cleavage in plane polarised light, and very high order interference colours, Fig. 3b, under crossed nicols.

Intergranular pockets of fine grained foliaceous and radiating prismatic crystals of talc together with rare chlorite (var. sheridanite) occur. In places the prismatic clusters of talc appear to have formed at the expense of the magnesite, perhaps as a result of a retrograde thermal metamorphism with its formation being ascribed to a reaction between the magnesite and silica. One subhedral porphyroblast of plagioclase felspar occurs in the thin section.

Fig. 3a. Photomicrograph, x 24, of thin section of specimen I_6 under plane polarised light, consisting dominantly of magnesite with minor talc and rare chlorite.

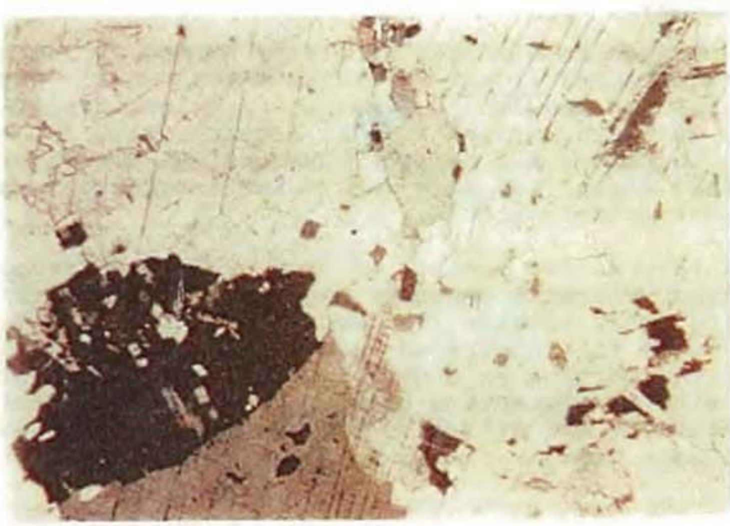


Fig. 3b. Photomicrograph of thin section of specimen I_6, mag x 24, under crossed nicols showing the occurrence of small equigranular and prismatic crystals of talc penetrating and interstitial to coarse anhedral magnesite.

Specimen I7

This specimen of wallrock is a quartz-muscovite-garnet schist (Figs. 4a, 4b, and 4c) containing some accessory actinolite, brown hornblende, talc and rare biotite.

The muscovite (var. phengite) forms long lenticular bands showing a preferred orientation in a matrix of interlocked equigranular quartz grains displaying strongly irregular grain boundaries. Large euhedral porphyroblasts of garnet, forming one of the major phases, are dispersed throughout the rock.

Accessory subhedral tabular and rhombic sections of actinolite (colourless to bluish green pleochroism) occur orientated parallel to the schistosity. The actinolite also occurs as rims to euhedral grains of rhombic and tabular outline which may have originally been brown hornblende but now are pseudomorphed by what appears to be a mixture of talc, chlorite and residual hornblende. Some talc is present as small pockets within the muscovite layers but this identification is based on the form, the lower refractive index and the occurrence of dusty inclusions. The colour, birefringence etc. of the talc is otherwise the same as muscovite.

In polished section the main opaque accessory mineral is pyrrhotite occurring as subhedral laths lying parallel to the schistosity. Traces of chalcopyrite also occur, and some rutile rods mainly as inclusions in the garnet porphyroblasts.

Fig. 4a Photomicrograph of polished section of I7 showing pyrrhotite (white), garnet (light grey), and muscovite-quartz (darker grey). Very dark to black areas are pits in the surface.

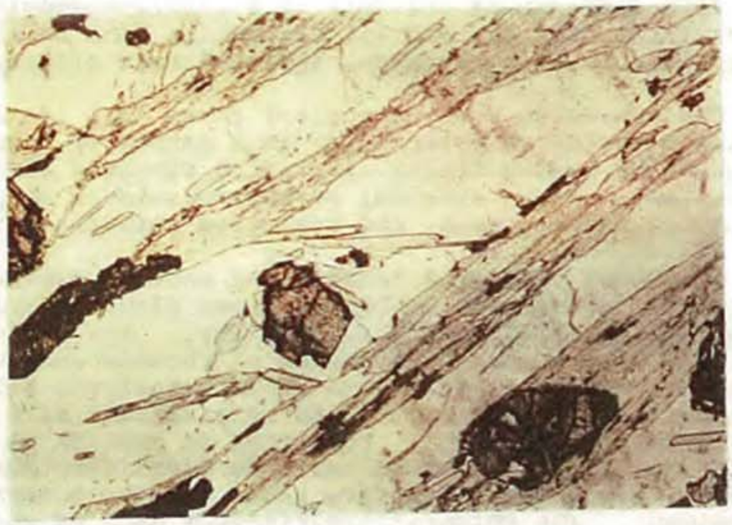


Fig. 4b. Photomicrograph, mag. x 40, of thin section of I_7 consisting of garnet, muscovite and quartz under plane polarised light.

Fig. 4c. Photomicrograph, mag. x 40, of thin section of I_7 under crossed nicols showing subhedral garnet (black), anhedral interlocking quartz (white-grey-black), and lamellar muscovite (coloured).

Specimen I_8

In hand specimen I_8 appears as a coarse aggregate of foliaceous talc varying in colour from white to greenish white. The general texture in thin section is of coarse foliated talc preferentially orientated and alternating with long lenses of a finer talc in which a preferred orientation appears to be absent as a result of shearing parallel to the schistosity. Minor chlorite (var. sheridanite) occurs as orientated laths intimately intergrown with the coarse talc and as fibrous aggregates in the finer talc lenses. Rare anhedral garnet, possibly pyrope, occurs.

In thin section the talc which appears greenish in hand specimen is seen to be crowded with minute inclusions of a pinkish mineral occurring as rounded to thin tabular grains and having a lower refractive index than the talc. A grey-brown amorphous material is also present. This material together with the granular inclusions is presumably responsible for the greenish colouration of the talc in hand specimen. As in I_3 and I_5 the greenish talc has been cleansed of inclusions along planes parallel to the schistosity by some later metasomatic process or retrograde metamorphic process. This 'absorbtion' of the inclusions by the talc or removal of the inclusions does not effect the form of aggregation of the talc crystals. Boundaries between the clean transparent and 'murky' talc often transgress the schistosity and there is no change in the coarseness or mode of aggregation of the talc across such boundaries. X-ray diffraction of the transparent white talc and the translucent greenish talc revealed no differences and the composition of these inclusions is at the moment unknown. Figure 5, under crossed nicols, shows such a transgressive boundary between the clear and 'murky' or dusty talc.

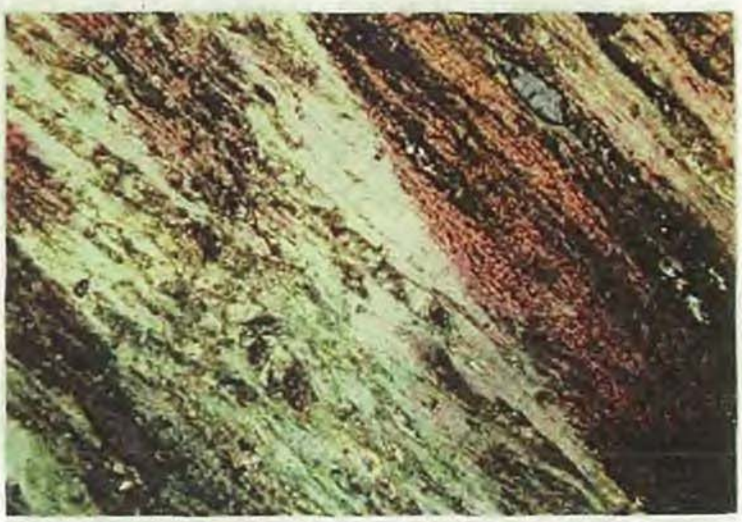


Fig. 5. Photomicrograph, mag x 24, of thin section I_8 showing the nature of the talc intergrowth under crossed nicols, and the transgressive boundaries between clear transparent talc and the inclusion-rich 'murky' talc which appears greenish white in hand specimen.

Specimen I_9: 'Grey talc lst face'.

In specimen I_9 talc and chlorite (var. sheridanite) are the main constituents. They occur intimately intergrown as long orientated foliaceous aggregates alternating with finer platy aggregates in which the talc and chlorite fibres are randomly orientated and which form lenses elongated parallel to the schistosity of the coarser foliaceous talc (Figs. 6a and 6b). As in previous sections the talc appears murky in parts due to the presence of minute unidentifiable inclusions.

The talc is also crowded with small irregular and rod-shaped grains of rutile . Rare subhedral porphyroblasts of garnet (possibly pyrope) also occur.

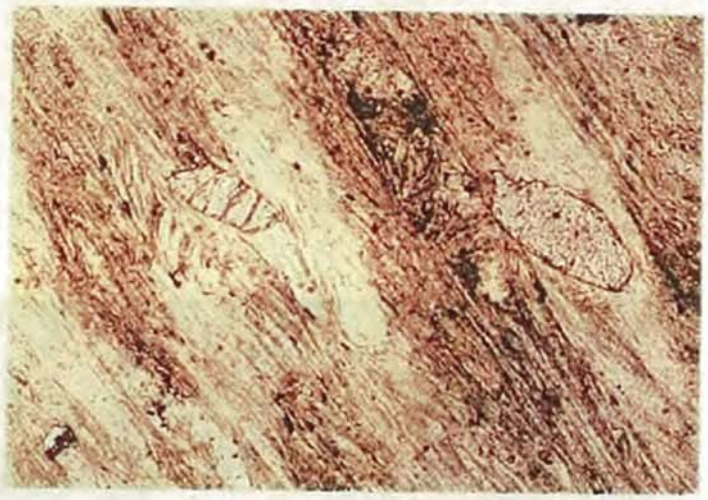


Fig. 6a Photomicrograph, x 40 mag, of thin section I_9 under plane polarised light showing subhedral garnet grains in an orimntated foliaceous aggregate of talc and chlorite.

Fig. 6b. Photomicrograph, x 40 mag., of thin section I_9 under crossed nicols showing garnet (black) in a coarse matrix of foliaceous talc (bright interference colours) and chlorite (white to blue-grey interference colours).

Specimen I_{10} and I_{10A}: 'granular talc'

Both I_{10} and I_{10A} consist of an intergrowth of medium grained and randomly orientated major talc with minor chlorite (var. sheridanite) (Fig. 7). Some small porphyroblasts of garnet also occur scattered in the talc/chlorite ground mass. In this specimen the talc is not crowded with inclusions as is the case in most of the other samples.

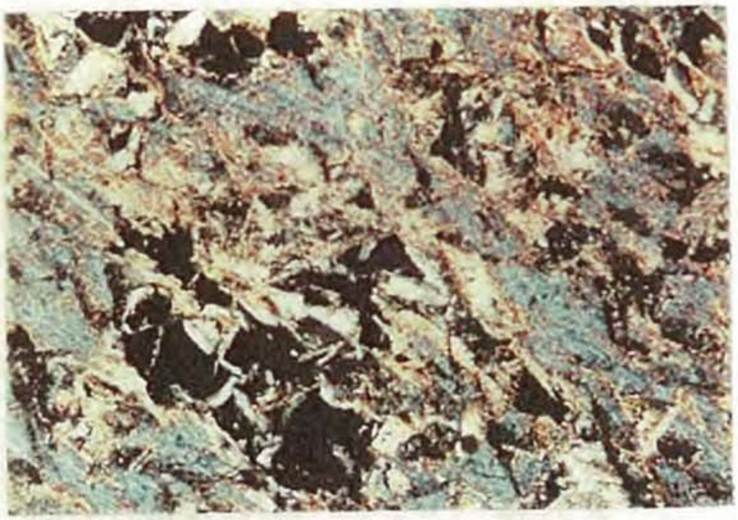


Fig. 7. Photomicrograph, x 40 mag., of thin section I_{10}, under crossed nicols, consisting of talc (blue and yellow interference colours), chlorite (white and greys), and garnet (black).

Specimen I_{11} : 'carbonate and talc'

Specimen I_{11} consists dominantly of a mosaic of coarse to fine grained anhedral interlocking magnesite grains with interstitial pockets of coarse to medium grained foliaceous aggregates of talc (Figs. 8a and 8b). The talc is crowded with near sub-microscopic inclusions of a transparant phase together with a brown amorphous material which causes the talc to appear dusty or turbid in thin section. Some fibrous chlorite (var. sheridanite) occurs as small pockets intergrown with the talc. Traces of rutile and pyrite occur.

Fig. 8a. Photomicrograph, x 24 mag., of thin section I_{11} under plane polarised light showing a subhedral pyrite metacryst (black) in a matrix of compact granular magnesite with interstitial foliaceous talc (top centre).

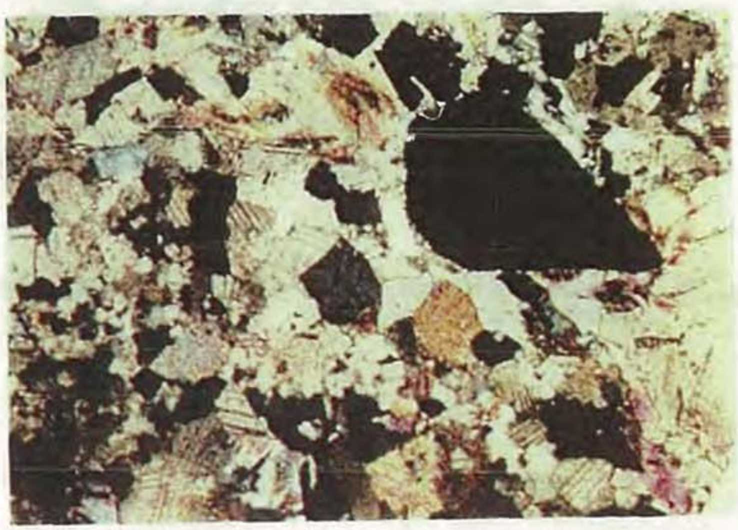


Fig. 8b. Photomicrograph, x 24 mag., of thin section I_{11} under crossed nicols showing a pyrite metacryst (black) in a granular magnesite matrix, with a foliaceous interstitial aggregate of talc (top centre).

Specimen I_{12}

An aggregate of anhedral quartz as the main constituent with minor interstitial muscovite and green chlorite (var. pennine) Fig. 9. The long muscovite laths show a preferred orientation. Chlorite occurs in interstitial pockets as randomly orientated platy grains. Some epidote is present and a trace of magnesite.

The chlorite displays a pleochroism from light green to brownish-cream, and anomalous blue interference colours in some cases. However, most of the chlorite grains display lower second order to upper first order interference colours. Thus a range of chlorite composition is probably represented in the section.

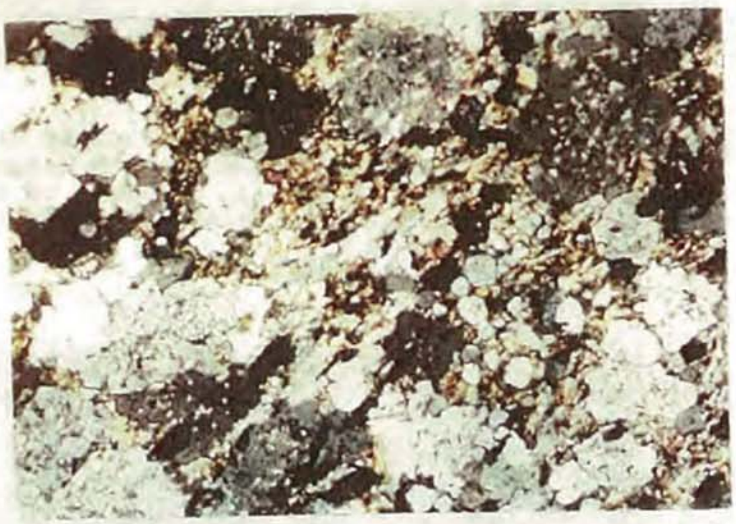


Fig. 9. Photomicrograph, x 40 mag., of thin section I_{12} under crossed nicols.

Specimen I_{13}

This specimen consists of an aggregate of mainly medium grained platy to fibrous chlorite (var. sheridanite) and equigranular quartz. These two enclose ragged replacement residuals of calcite and subhedral metacrysts of pyrite with rare chalcopyrite.

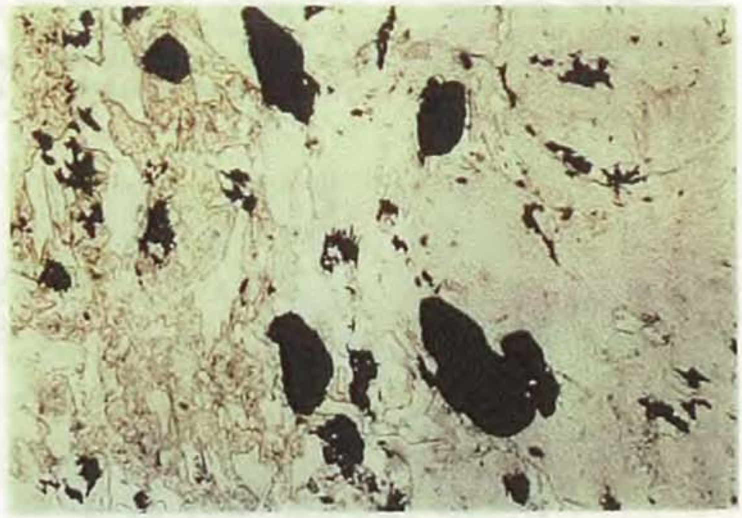


Fig. 10a Photomicrograph, x 40 mag., of thin section I_{13} under PPL showing subhedral pyrite metacrysts (black) in a matrix of dominantly chlorite and quartz with minor calcite.

Fig. 10b Photomicrograph, x 40 mag., of thin section I_{13} under XN showing chlorite (fibrous white and greenish-grey) and calcite (coloured) enclosing subhedral grains of pyrite (black). Equigranular grey grains are quartz.

Specimen I_{14}

This specimen is dominantly composed of very coarse grained magnesite enclosing minor amounts of talc and very minor chlorite (var. sheridanite). The talc and chlorite form pockets of radiating lamellar and foliaceous crystals as in Figs. 11a, 11b.

Fig. 11a Photomicrograph, x 24 mag., of thin section I_{14} under PPL of coarse magnesite and intergranular pockets of 'dusty' and 'clear' talc.

Fig. 11b Photomicrograph, x 24 mag., of thin section I_{14} under XN of magnesite (greenish) and pockets of radiating lamellar talc (blue, purple, yellow).

Specimen I_{15A}

This specimen of wallrock is a garnet-muscovite-quartz schist with minor green chlorite, biotite, and rare talc and feldspar (Figs. 12a and 12b).

The garnet occurs as large (1-3mm diam.) porphyroblasts altered along irregular fractures to a mixture of greenish chlorite, biotite, and some feldspar, and enclosed in a matrix composed of orientated tabular grains of muscovite, forming elongated lenses, and alternating with 'mosaic' granular quartz containing randomly dispersed biotite and chlorite flakes.

Fig. 12a Photomicrograph, x 24 mag., of thin section I_{15A} UNDER PPL showing a large altered porphyroblast of garnet in a matrix of dominantly muscovite with minor quartz.

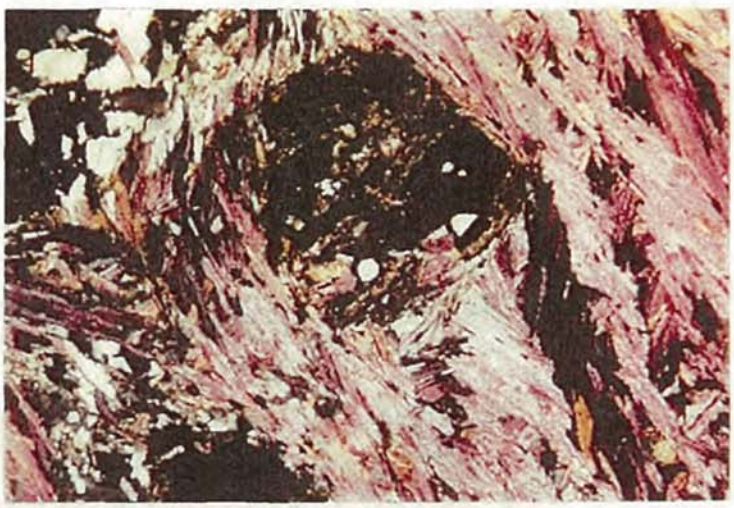


Fig. 12b. Photomicrograph, x 24 mag., of thin section I_{15A} under crossed nicols. Garnet (black). Muscovite (dominantly purple interference colours). Quartz (white and greys).

Specimen I_{15}

This specimen is dominantly composed of chlorite (var. sheridanite) and quartz as orientated aggregates producing a schistosity. Very minor amounts of magnesite and talc occur. The talc occurs as thin laths intergrown with the chlorite (Fig. 13b).

Fig. 13a Photomicrograph, x40 mag., of thin section I_{15} under PPL showing the irregular but preferred elongation of granular quartz segregations in a matrix of fibrous chlorite (var. sheridanite).

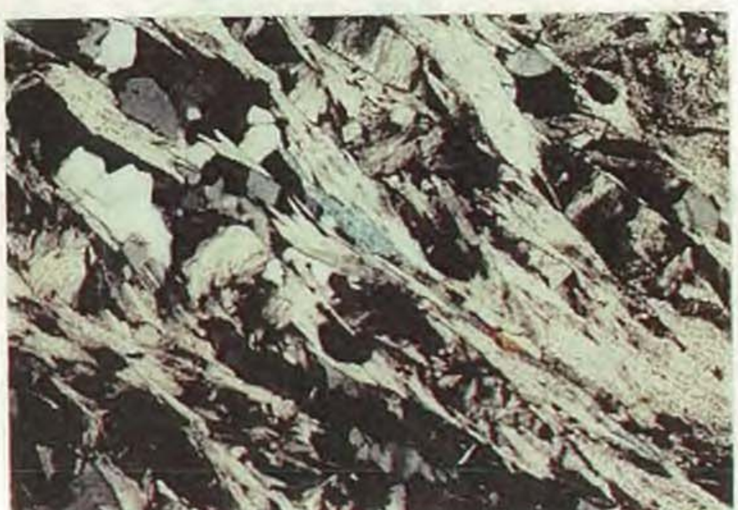


Fig. 13b Photomicrograph, x 40 mag., of thin section I_{15} under XN, composed of chlorite (fibrous white, greenish grey, black), quartz (granular white-grey-black), and talc (blue, red, and yellow interference colours).

Specimen I_{16}: 'first face inclusion'

This specimen is composed of a medium grained aggregate of dominantly chlorite (var. sheridanite) and quartz, with minor magnesite, clinozoisite, talc, and muscovite, and displaying a poor schistosity. Scattered euhedral to sub-hedral pyrite metacrysts occur as well as medium grained crystal aggregates of rutile associated with clinozoisite forming 'stringers' parallel to the general schistosity of the rock.

In the photomicrograph of figure 14a the brownish speckled areas are dominantly chlorite although in Figure 14b talc and muscovite are more apparent because of their interference colours.

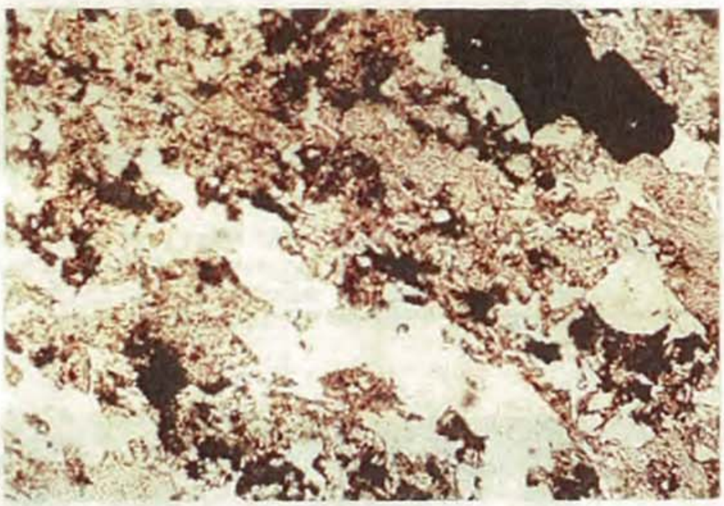


Figure 14a Photomicrograph, x 40 mag., of thin section I_{16} under PPL.

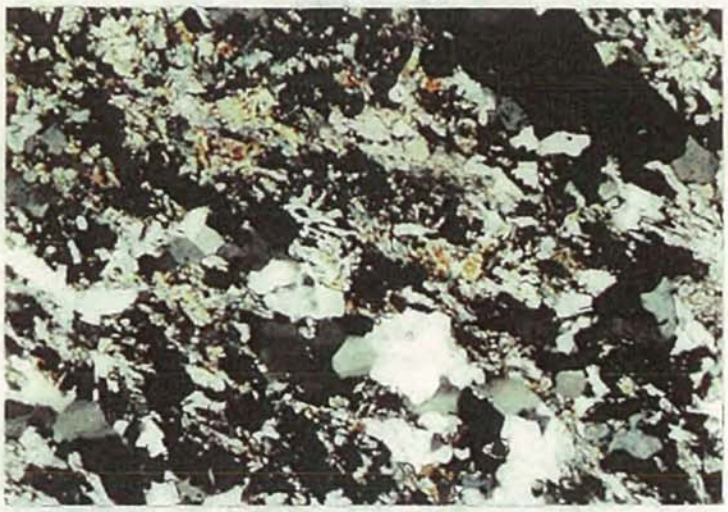


Fig. 14b Photomicrograph, x 40 mag., of thin section I_{16} under crossed nicols. A chlorite - quartz rock with minor talc and muscovite, and accessory magnesite, clinozoisite, rutile and pyrite.

Specimen I_{17}: 'footwall'

This specimen of footwall rock is a muscovite-quartz-garnet schist consisting of long lenticular anhedral quartz aggregates. Both are enclosing fractured and altered euhedral porphyroblasts of garnet. Accessory sphene also occurs as well as serpentine-quartz pseudomorphs after a mineral displaying rhombic and tabular sections.

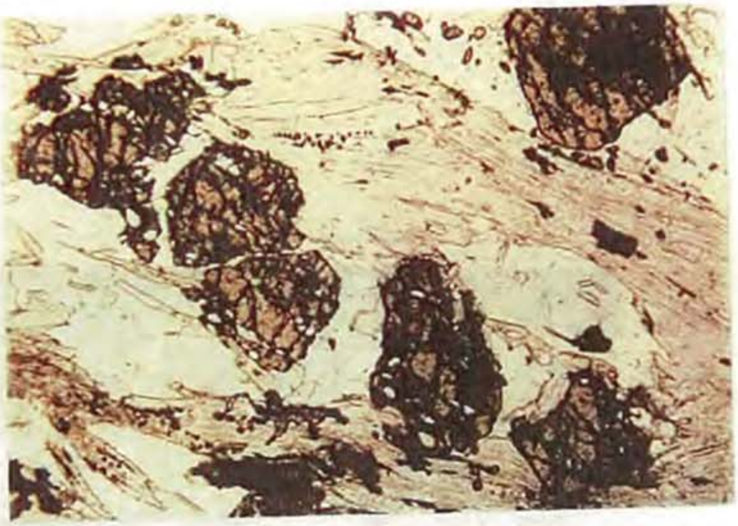


Fig. 15a Photomicrograph, x 24 mag., of thin section I_{17} under PPL showing garnet euhedra in a matrix of segregated quartz and muscovite.

Fig. 15b Photomicrograph, x 24 mag., of thin section I_{17} under XN. Garnet (black), quartz (white to grey), and muscovite (lamellar and coloured).

Specimen I_{18}: 'Face 3, carbonate/talc'

A coarse to medium grained aggregate of subhedral interlocking grains of magnesite with minor talc occurring as scattered small interstitial clusters associated with rare chlorite (var. sheridanite) and muscovite (Figs. 16a, 16b).

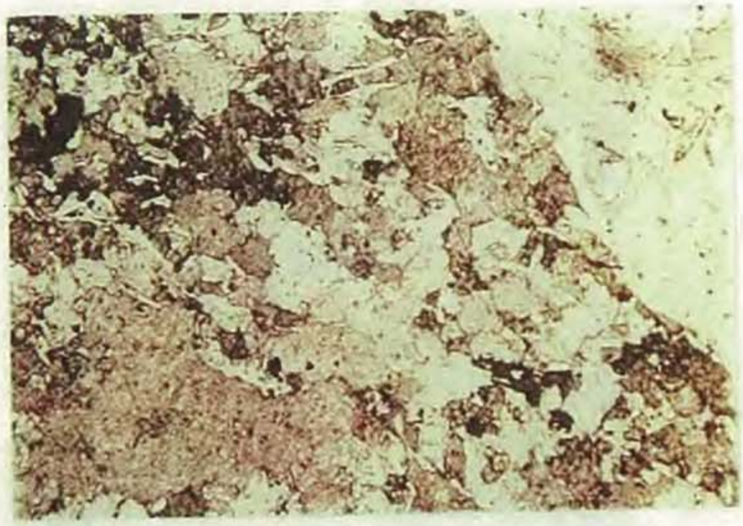


Fig. 16a Photomicrograph, x 24 mag., of thin section I_{18} under PPL of granular magnesite with scattered tabular crystals and clusters of talc.

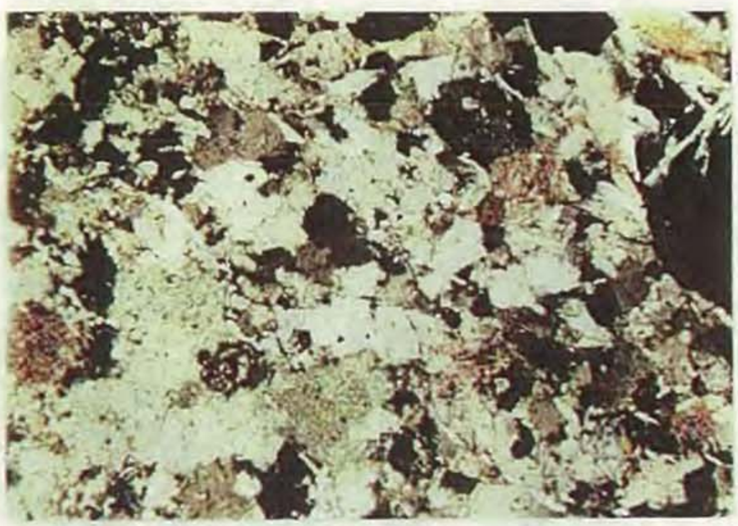


Fig. 16b Photomicrograph, x 24 mag., of thin section I_{18} under XN of granular magnesite (high order interference colours, and scattered tabular crystals and clusters of talc (top right, coloured) and rare chlorite (white to blue-grey colours).

Specimen I_{19}:

This specimen consists of an aggregate of coarse grained anhedral magnesite intergrown with solitary bladed crystals and crystal aggregates of tremolite associated with minor amounts of fine fibrous talc and rare anhedral grains of quartz (Figs. 17a, 17b).

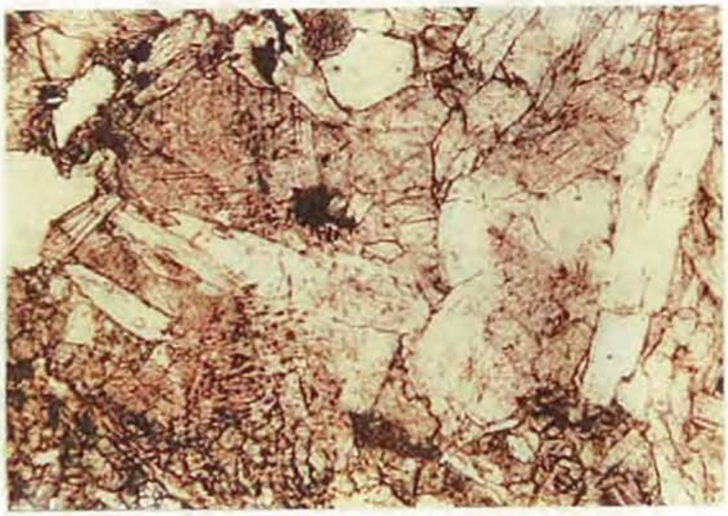


Fig. 17a Photomicrograph, x 24 mag., of thin section of I_{19} under PPL, showing coarse bladed tremolite intergrown with very coarse grained magnesite.

Fig. 17b Photomicrograph, x 24 mag., of thin section I_{19} under crossed nicols showing coarse bladed tremolite and anhedral coarse-grained magnesite with minor small fibrous aggregates of talc (top left).

Specimen I_{21}: 'Inclusion, face 2'.

Specimen I_{21} is composed of a fine grained interlocking aggregate of anhedral magnesite, as the major constituent, associated with scattered laths and interstitial fine-grained fibrous aggregates of very minor talc (Figs. 18a and 18b).

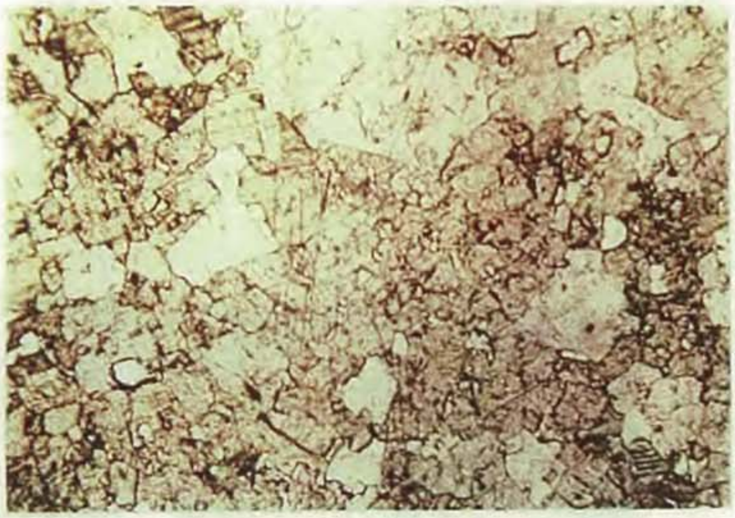


Fig. 18a Photomicrograph, x 24 mag., of thin section I_{21} under PPL. Magnesite with rare talc.

Fig. 18b Photomicrograph, x 24 mag., of thin section I_{21} under crossed nicols. Magnesite with rare talc.

Specimen I_{22}

This specimen is dominantly composed of coarse subhedral to euhedral interlocking grains of magnesite associated with intergranular fibrous clusters of talc which often enclose smaller euhedral magnesite grains (Fig. 19).

Fig. 19 Photomicrograph, x 24 magnification, of thin section I_{22} under plane polarised light. Magnesite and interstitial aggregates of talc.

Specimen I_{23}: 'Black Gneiss 2' below talc vein'

Specimen I_{23} consists dominantly of medium grained anhedral interlocking quartz as orientated bands enclosing large microcline anhedra and anhedral aggregates. Scattered platy aggregates of muscovite occur orientated parallel to the general direction of the quartz banding. Minor epidote and chlorite also occur (Figs. 20a and 20b).

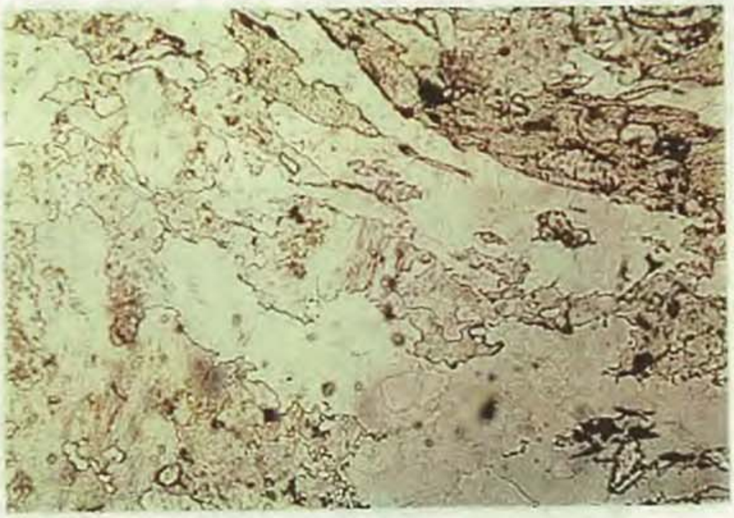


Fig. 20a Photomicrograph, x 24 mag., of thin section I_{23} under PPL. Quartz-muscovite-microcline gneiss.

Fig. 20b Photomicrograph, x 24 mag., of thin section I_{23} under XN. Quartz-muscovite-microcline gneiss.

Specimen I_{24}: 'Face 2, Talc next to carbonate'

This specimen of talc ore consists dominantly of coarse fibrous talc with minor chlorite (var. sheridanite) occurring as small lenticular fibrous aggregates within the main mass of talc (Figs. 21a and 21b). A few small subhedra of garnet are present. As in previous specimens there are two forms of talc present: (1) a talc that in thin section appears brown (Fig.21a) under plane polarised light due to finely dispersed dusty inclusions of a transparant mineral and a brown amorphous material, (2) a clear transparant talc free of inclusions which appears to have been formed at the expense of the other by some metasomatic 'cleansing' process. Talc crystals in optical continuity can be seen to change sharply from 'dusty' brown talc to the clear talc.

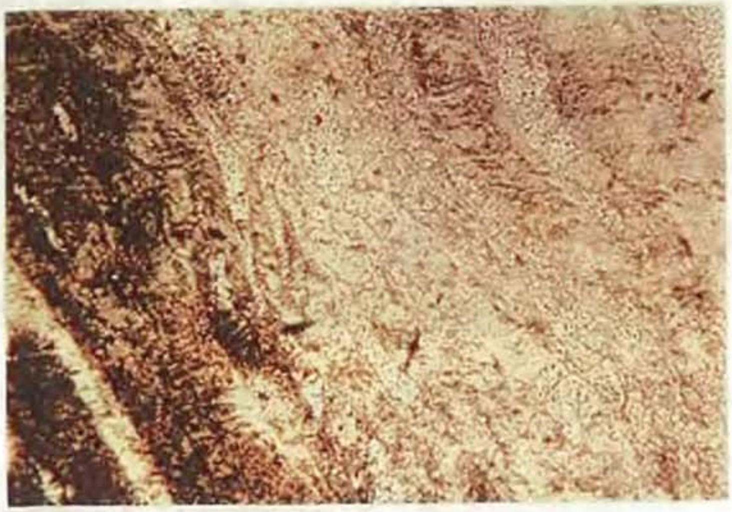


Fig.21a Photomicrograph, x 24 mag., of thin section I_{24} under PPL. 'Dusty' and clear talc enclosing small lenticular aggregates of chlorite.

Fig.21b Photomicrograph, x24 mag., of thin section I_{24} under XN. Coarse talc with lenticular aggregates of chlorite.

Specimen I_{25}

This specimen of footwall rock consists of an interlocking aggregate of medium grained anhedral quartz enclosing occasional large anhedra of microcline feldspar (Figs. 22a,22b). Minor magnesite occurs as pockets interstitial to the quartz, and also scattered laths of muscovite. Green chlorite (pennine) and epidote occur in trace amounts.

Fig. 22a Photomicrograph, x 24 mag., of thin section I_{25} under PPL; dominantly a quartz-microcline rock with minor muscovite and rare pennine and epidote.

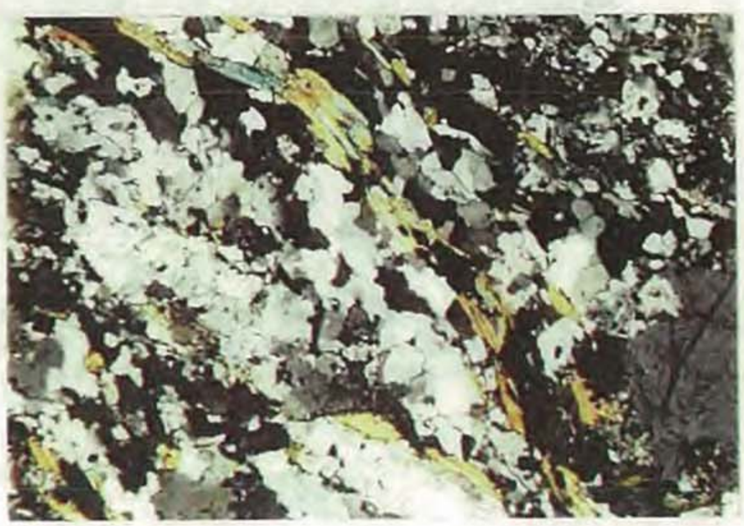


Fig. 22b Photomicrograph, x 24 mag., of thin section I_{25} under XN.

Specimen I26

This specimen contains chlorite, talc, magnesite and rutile. One part of the thin section consisted of a massive coarse fibrous and feathery aggregate of talc enclosing pockets of coarse magnesite. This texture graded into one which was dominantly fine grained chlorite (var. sheridanite) intimately intergrown with minor quantities of fibrous and platy talc (Fig. 23) as well as scattered small equigranular and rod-shaped rutile crystals.

Fig. 23. Photomicrograph, x 40 mag., of thin section I_{26} under crossed nicols showing minor talc (coloured) intimately intergrown with major chlorite.

Specimen I_{27}

Specimen I_{27} is dominantly composed of quartz, chlorite (var. sheridanite) and talc (Figs. 24a and 24b). Thin lenticular bands of coarse feathery talc and chlorite alternate with anhedral granular interlocking aggregates of quartz. Scattered inclusions of rutile and epidote occur, as well as occasional large microcline anhedra.

Fig. 24a Photomicrograph, x 40 mag., of thin section I_{27} under PPL, showing a fibrous and feathery aggregate of talc and chlorite enclosing anhedral segregations of quartz.

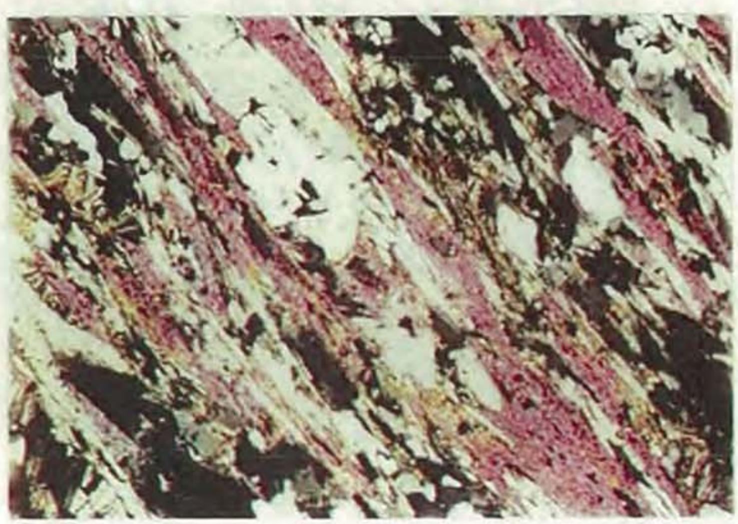


Fig. 24b Photomicrograph, x 40 mag., of thin section I_{27} under XN.

Specimen I_{29}

Specimen I_{29} is a gneissic rock consisting of segregated bands of medium to fine interlocking anhedral quartz grains alternating with minor muscovite as orientated platy clusters, and enclosing large microcline anhedra. Some rare pennine and very rare epidote occur intergrown with the muscovite.

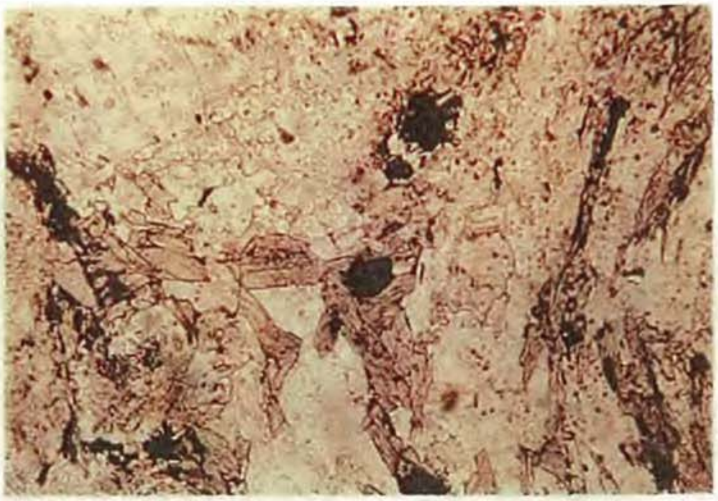


Fig. 25a Photomicrograph, x 24 mag., of thin section I_{29} under PPL; quartz, muscovite, and microcline (top left).

Fig. 25b. Photomicrograph, x 24 mag., of thin section I_{29} under XN.

Specimen I_{31}

Specimen I_{31} is a muscovite-quartz schist containing minor pennine, sphene and tremolite.

The rock is dominantly made up of coarse orientated lamellar segregations of muscovite intergrown with flakes of minor greenish brown chlorite (pennine) and enclosing euhedral to subhedral grains of sphene. Minor interlocking fine to medium grained quartz segregations occur alternating with the muscovite bands. Hexagonal sections of an amphibole, probably tremolite, occur dispersed in the muscovite matrix.

Fig. 26a Photomicrograph, x 40 mag., of thin section I_{31} under PPL; muscovite-quartz schist.

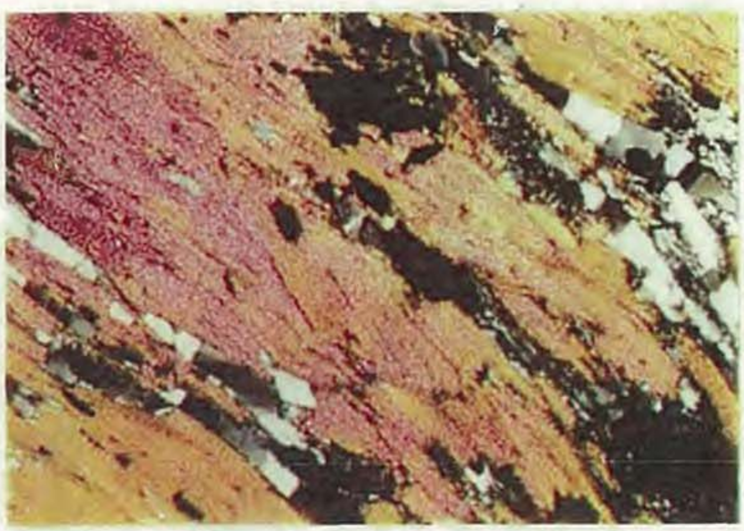


Fig. 26b Photomicrograph, x 40 mag., of thin section I_{31} under XN; muscovite-quartz schist.

Specimen I_{32}

This specimen consists of coarse feathery lenticular aggregates of dominantly chlorite (var. sheridanite) intimately intergrown with minor amounts of talc (Figs. 27a and 27b).

Small inclusions of rutile occur along the boundaries (shear planes) between the chlorite aggregates and also along chlorite cleavage planes. Finely dispersed submicroscopic dusty inclusions of an unidentified phase similar to that found in talc occur in the chlorite.

Fig. 27a Photomicrograph, x 24 mag., of thin section I_{32} under XN. Feathery aggregates of sheared chlorite (white to greenish grey to black) with minor talc (coloured).

Fig. 27b Photomicrograph, x 24 mag., of thin section I_{32} under XN. Finer grained chlorite-talc mixture.

Specimen I_{33}

This specimen of talc ore consists of a medium to fine grained randomly orientated intergrowth of dominantly talc with minor chlorite (var. sheridanite). The chlorite is intimately mixed with the talc (Fig. 28). Some pockets of coarse interlocking anhedral magnesite grains occur enclosed by the talc-chlorite matrix.

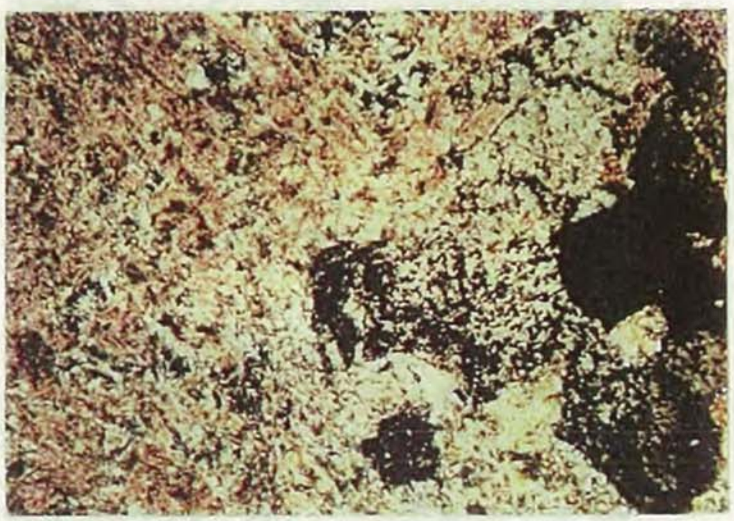


Fig. 28 Photomicrograph, x 24 mag., of thin section I_{33} under XN.

Specimen I_{35}

This specimen consists dominantly of magnesite as a very coarse to medium grained interlocking aggregate of euhedral to subhedral grains. Minor tremolite occurs as long prismatic crystals forming interstitial clusters, and as solitary crystals penetrating the magnesite and along the grain boundaries of the magnesite. Minor chlorite (var. sheridanite) and rare talc occur associated with the tremolite segregations. (Figs. 29a, 29b).

Fig. 29a Photomicrograph, x 24 mag., of thin section I_{35} under PPL. Magnesite-tremolite-chlorite-talc rock.

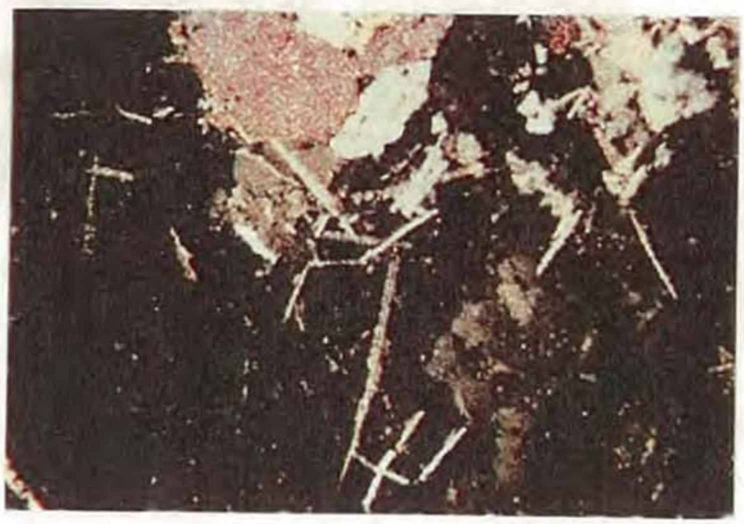


Fig. 29b Photomicrograph, x 24 mag., of thin section I_{35} under XN. Prismatic tremolite in magnesite in the extinction position.

Specimen I37

This specimen consists dominantly of magnesite with minor talc. The magnesite occurs as an aggregate of very large magnesite anhedra enclosed by finer grained subhedral magnesite which is intergrown with feathery intergranular clusters of talc (Fig. 30).

Fig. 30 Photomicrograph of thin section I37, x 24 mag., under XN showing the finer intergranular magnesite associated with small laths of talc (fibrous and coloured).

Specimen I_{39}

This specimen is dominantly composed of talc forming coarse feathery aggregates intimately intergrown with minor finer grained chlorite (var. sheridanite) and containing fine disseminated inclusions of rutile. Occasional fine grained quartz as well as larger oval-shaped augen of quartz and rare garnet occur scattered throughout the talc matrix. The talc is for the most part crowded with inclusions, as in previous sections, but elongate areas of 'clean' talc occur as in Fig. 31a.

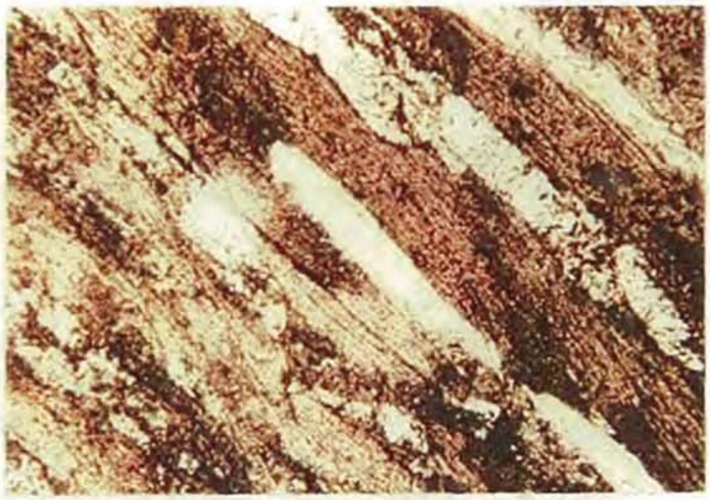


Fig. 31a Photomicrograph, x 24 mag., of thin section I_{39} under PPL.

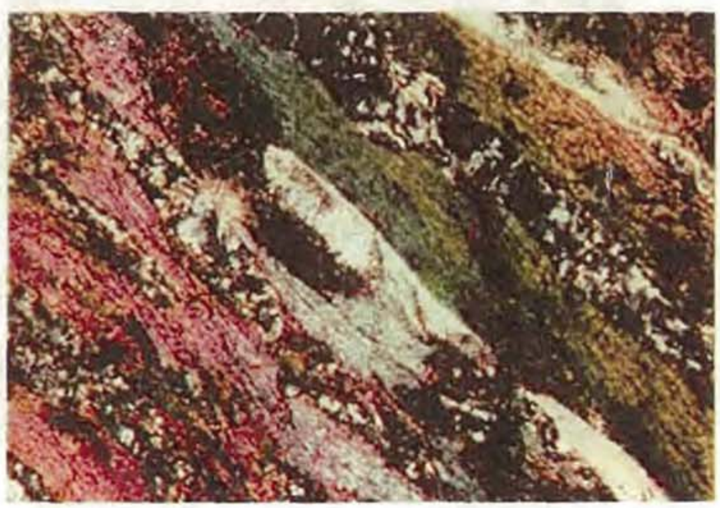


Fig. 31b Photomicrograph, x 24 mag., of thin section I_{39}, under XN

Specimen I_{41}

This specimen of talc ore consists of a coarse aggregate of feathery talc intimately intergrown with minor chlorite (var. sheridanite), and enclosing rare large porphyroblasts of subhedral garnet which occasionally contain long prismatic inclusions of tremolite (Fig.32a).

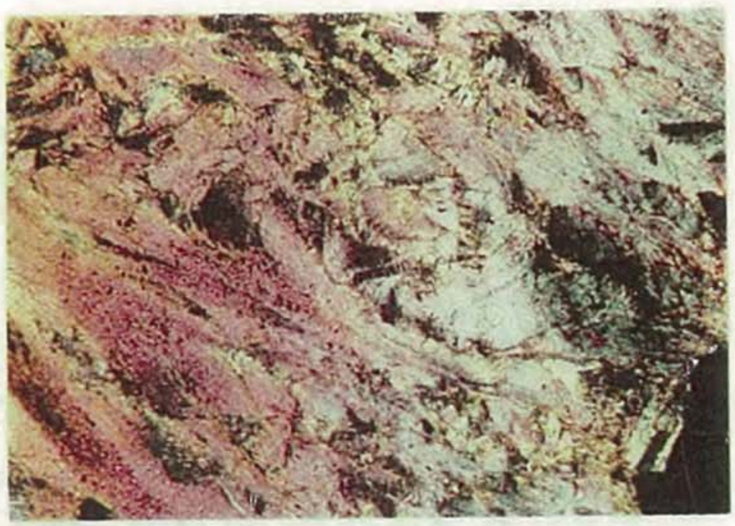


Fig. 32a Photomicrograph, x 24 mag., of thin section I_{41} under XN. Feathery aggregate of talc with garnet porphyroblast (bottom right, black).

Specimen I42: 'No.1 Face, green coloured'

Specimen I42 consists dominantly of an aggregate of fine grained fibrous chlorite (var. sheridanite) intimately intergrown with minor very fine grained talc as in Fig. 33.

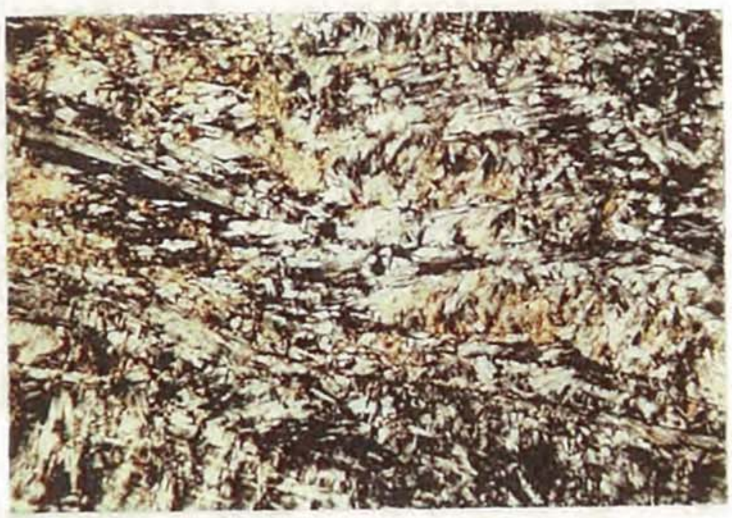


Fig. 33 Photomicrograph, x 24 mag., of thin section I42 under crossed nicols of chlorite (white, greenish grey, black), and fine grained talc (yellow).

Specimen I43: 'Face 10 fibrous sample'

Specimen I43 consists dominantly of chlorite (var. sheridanite), occurring in the form of a coarse sheared fibrous aggregate intimately intergrown with very minor talc as in Figure 34.

Fig. 34 Photomicrograph, x 40 mag., of thin section I43 unde crossed nicols showing deformed fibrous chlorite (white-greenish grey-black) intergrown with platy and prismatic crystals of talc (coloured).

Specimen I43A

As for I43 the specimen consisted dominantly of chlorite (var. sheridanite) with very minor talc. The 'cross fibre' type texture found in I43 and produced by shearing at right angles to the schistosity was absent in specimen I43A.

Specimen I_{44}: 'First face pure talc"

A coarse aggregate of lamellar talc showing a preferred orientation and enclosing augen of what appears to be an intimate intergrowth of quartz and serpentine (Fig. 35). Both talc crowded with fine unidentified inclusions and 'clear' talc are present. See also description for I_{45}.

Fig. 35 Photomicrograph, x 24 mag., of section I_{44} under crossed nicols showing coarse lamellar talc enclosing rare anhedral segregations of probable serpentine-quartz composition.

Specimen I_{45}: 'No.1 good specimen'

This specimen of 'talc ore' consists nearly wholly of talc occurring in the form of a randomly orientated 'matted' aggregate of fibrous talc enclosing minor quartz-serpentine augen. As in previous sections the talc is rendered murky or dusty by fine inclusions of a brown amorphous material and an unidentified transparant phase. In places the talc has been cleansed of these inclusions along zones which appear to be independent of any intergrowth or crystallographic features of the talc (Fig. 36).

Fig. 36 Photomicrograph, x 24 mag., of thin specimen I_{45} under crossed nicols showing the form of aggregation of the talc and the difference between the 'murky' talc and the linear transgressive zone of 'clear' talc.

Specimen I46: 'No.3 face, coloured'

This specimen consists of very coarse lenticular aggregates of long fibrous and feathery talc crystals enclosing rare anhedral porphyroblasts of garnet.

DIGESTIVE TESTS

To confirm the presence of acid soluble carbonate material and also to help identify the type of carbonate present in the rock specimens collected,each powder specimen was subjected to a digestive test.

Half gram quantities of each of the powders were treated with normal hydrochloric acid for several hours at approximately 70°C. The residues were reweighed and the filtrates were analysed for their calcium and magnesium content using the EEL, 240 Atomic Absorption Spectrophotometer. The aim of the digestion was not to estimate the total acid soluble fraction only to help establish the carbonate minerals present and to estimate roughly their quantity to help interpret the X-ray powder photographs obtained from the samples.

The results are present under three headings, namely 'Rock Types', 'Carbonate Specimens', and 'Talc Specimens'.

It can be seen that only small quantities of carbonate material are present in the talc specimen group, similarly in the rock specimens with the exception of the marble specimen which is practically 100% calcite. The carbonate group of specimens appear to be mixtures of calcium and magnesium carbonate with a number of specimens being possible dolomites.

ROCK TYPES

Specimen No.	% Weight Loss	% Calcium	% Magnesium
I1	<0.2%	<0.2%	<0.2%
I7	3.0%	<0.2%	<0.2%
I12	<0.2%	<0.2%	<0.2%
I13	4.2%	1.0%	0.4%
I15	6.0%	<0.2%	0.4%
I16	4.8%	2.0%	0.4%
I17	6.0%	<0.2%	<0.2%
I20	11.2%	<0.2%	<0.2%
I23	1.4%	<0.2%	<0.2%
I25	22.4%	<0.2%	<0.2%
I27	9.0%	<0.2%	<0.2%
I29	3.6%	<0.2%	<0.2%
I31	9.6%	<0.2%	<0.2%
I34	92.2%	>20.0%	<0.2%

CARBONATE SPECIMENS

Specimen No.	% Weight Loss	% Calcium	% Magnesium
I4	22.8%	3.0%	1.1%
I6	48.0%	6.0%	1.15%
I11	21.6%	3.0%	6.4%
I14	44.2%	7.0%	5.0%
I18	75.2%	14.0%	24.0%
I19	37.8%	5.0%	4.0%
I21	61.8%	8.4%	8.0%
I22	91.2%	16.0%	15.2%
I30	15.0%	1.9%	1.6%
I35	50.8%	6.6%	13.4%
I37	51.0%	4.4%	24.0%

TALC SPECIMENS

Specimen No.	% Weight Loss	% Calcium	% Magnesium
I2	3.6%	<0.2%	0.4%
I3	1.6%	<0.2%	<0.2%
I5	5.4%	<0.2%	<0.2%
I8	6.0%	<0.2%	<0.2%
I9	<0.2%	<0.2%	<0.2%
I10	4.2%	<0.2%	<0.2%
I24	8.0%	<0.2%	<0.2%
I26	<0.2%	<0.2%	<0.2%
I28	12.6%	<0.2%	<0.2%
I32	1.2%	<0.2%	0.4%
I33	5.6%	0.34%	<0.2%
I36	4.6%	<0.2%	<0.2%

/Continued....

TALC SPECIMENS (Continued)

Specimen No.	% Weight Loss	% Calcium	% Magnesium
I38	1.0%	<0.2%	<0.2%
I39	<0.2%	<0.2%	<0.2%
I40	7.0%	<0.2%	<0.2%
I41	<0.2%	<0.2%	<0.2%
I42	0.8%	<0.2%	<0.2%
I43	6.2%	<0.2%	<0.2%
I44	<0.2%	<0.2%	<0.2%
I45	8.0%	<0.2%	<0.2%

Electron Microscope Examination of Italian Mine Samples and Imported Batch Shipments of Italian Powder

The main purpose of the electron microscope examination of mine samples and also representative fractions of the Italian powder has been to establish whether or not any particles corresponding to the commercial forms of asbestos were present. The electron microscope is an instrument which is most usefully employed in the examination of particles less than ten microns in size. It has been used in this investigation therefore to examine only the finer particulate portion of the Italian samples. It may be argued that only a small fraction of each of the powdered samples was examined and that this was not representative of the total sample. However, we can assume that the fraction examined was representative of the dust formed from each sample and that it is this finer fraction which is the most important from a biological standpoint. Also as the size of the biologically active commercial asbestos particles fall entirely within the particle size range examined we can consider the main aim of the examination to be entirely satisfied by only looking at the finer fractions from each of the Italian samples.

To acquaint ourselves with the type of particles formed by the commercial asbestos minerals, Figs. have been included. They represent samples of Amosite, Crocidolite, Anthophyllite and Chrysotile asbestos. Also Figs. have been inserted to demonstrate typical single particle electron diffraction patterns which can be obtained from the four asbestos types for comparison with patterns obtained from the Italian samples.

Sample Preparation

Small portions of the powdered rock samples and imported powder specimens were placed in 15cc centrifuge tubes to which distilled water was added. The powders were then dispersed first by hand shaking and then with the aid of a small ultrasonic bath. The concentration of suspended material in the tubes was adjusted by eye using dilutions of distilled water. The tubes containing suspended solids were then allowed to stand for 20 minutes to allow the larger particles of mineral to sediment to the bottom of the tubes.

Electron microscope grids coated with carbon films were prepared and small drops of the particulate material from each of the specimen tubes were mounted on specimen grids and allowed to dry. The specimens were inserted into an A.E.I. E.M.6. electron microscope and examined for particles resembling commercial asbestos fibres. Where suitable particles were observed, selected area electron diffraction patterns were produced by the commercial asbestos minerals. In all cases photomicrographs representative of the type of particles found in each sample were taken while interesting diffraction patterns were also recorded.

Particle Morphology

The carbonate rich materials were found to produce compact particles which were very electron dense. On the whole they were finer particles than those obtained after crushing talc rich specimens. No fibrous material whatsoever was found when carbonate material only was comminuted. The morphology of particles produced from the footwall rocks i.e. limestone, marble, gneiss and the amphibolites were also very compact, although in the gneiss specimen platey particles were present probably representing the muscovite content of the specimen. Again in the footwall rock specimens fibrous particles were very scarce. Those lath like particles detected resembled the amphibole minerals rather than chrysotile. Selected area diffraction patterns which were obtained from the lath like particles in no way resembled the typical amphibole fibre diffraction pattern. They were generally very distorted patterns containing streaks rather than spots indicating a rather stressed and deformed material.

The specimens which were composed of talc together with other mineral associations, presented a very different picture, as far as particle shape was concerned. In the main particles were flat and plate-like, some being very thin and translucent in the electron beam. Particle sizes varied from very small to quite large plates some with very sharp discrete edges, others with rather ragged outlines. Comparing particles from those samples of talc which varied in bulk morphology in hand specimens, no observable difference could be drawn between them. Similarly, a comparison of particles produced from talc specimens of varying colour revealed no differences in the overall particle shape. The same thing applied to those specimens with talc rich specimens, again no distinct differences in the type of particles formed during comminution of the bulk specimens were observed.

There were, however, observable differences in particle morphology between individual powder specimens. In the main most produced good plate like particles, however, one or two specimens were found to contain considerable numbers of lath like particles, these being very thin in character. These particles resembled the amphibole asbestos type particle being less regular and also very much larger in projected diameter. Diffraction patterns from these particles matched those obtained from the platy particles with which they were associated and in no way resembled the typical amphibole diffraction pattern obtained from single amphibole asbestos fibres.

Other fibrous particles were observed in the mainly talc specimens which to some extent resembled chrysotile asbestos fibres rather than amphibole minerals. They often had a somewhat textile appearance but were, however, crystalline. Diffraction patterns from these fibres were very distorted and in no way matched typical chrysotile or amphibole patterns.

The only group of specimens in which amphibole fibres were confirmed were in those specimens with known amphibole composition. However, even the fibres found in these specimens barely resembled the fibres formed by the commercial amphibole asbestos minerals. To assess the particles produced from the pure amphibole mineral (Tremolite), found in three of the specimens, small crystals of the mineral were taken from the hand specimens and crushed separately. An examination of the finer particles produced revealed stubby electron dense fibres associated with irregular lumps of the same mineral. Diffraction patterns from these fibres were similar to those obtained from the commercial amphibole minerals, although they were more difficult to obtain because of the greater thickness of these particles. Other specimens in the group, which did not contain talc but were composed of sheet silicate minerals mainly muscovite, were also practically free of fibrous particles. There appeared to be no general tendency for these other minerals to form fine fibrous particles. A number of very fine short fibres were observed on grids prepared from several of the talc specimens, these were, however, chance small pieces torn from the edges of talc plates. They appeared in those samples which had a tendency to form copius numbers of very fine particles when subjected to comminution.

The specimens examined can be grouped into four categories on the basis of particle morphology and they are as follows:

(a) Talc specimens with impurities of carbonate and chlorite.

(b) Rock type specimens, i.e. footwall limestone etc.

(c) Those specimens composed mainly of carbonates.

(d) Amphibole specimens with carbonate and talc.

The talc specimens were characterised by the large number of plate like particles often translucent in the electron beam. Rock specimens varied from specimens which were composed mainly of compact electron dense particles to those with some sheet silicate content in which plate like particles become apparent. Those specimens composed mainly of carbonate material produced compact rounded particles, often very small and grouped together in aggregates. Finally the specimens containing amphibole were characterised by the compact nature of the particles with evenly distributed fibres and very few translucent plates. The groups of particles described are illustrated by the following micrographs which illustrate the various forms.

Selected area electron diffraction patterns obtained from single particles of the amphibole mineral are also presented showing the similarity of these patterns to those obtained from commercial asbestos fibres. Also included are single crystals patterns and polycrystalline patterns, from talc, chlorite and muscovite rich specimens. It can be seen that they are very different in character to those obtained from the amphibole mineral. However, patterns from the sheet silicate minerals mentioned above are all very similar and it is impossible to identify each of these minerals from their

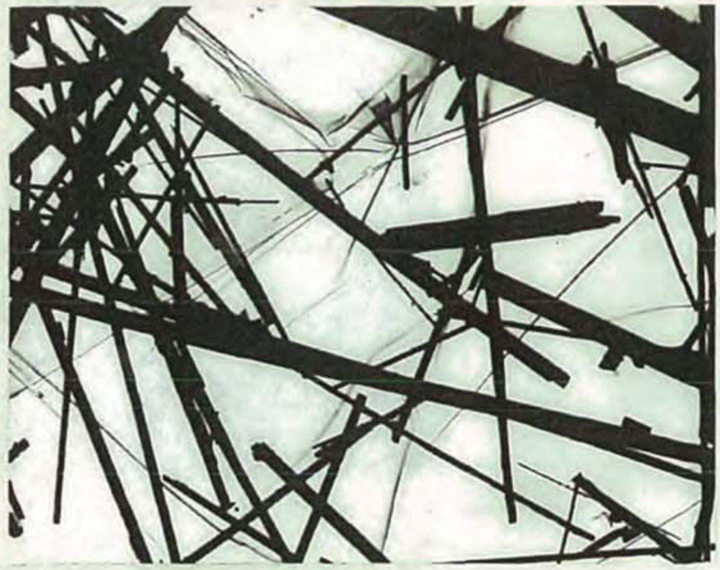
electron diffraction patterns or to tell them apart without applying a more sophistecated approach to the diffraction procedure. With specimen tilt facilities enabling the particle to be rotated through more than 45° discrimination is possible between certain of these minerals.

As mentioned earlier, patterns obtained from lath like particles found in the talc specimens were identical to those observed from general plate like forms. Those fibres with a textile like appearance often only gave very streaked patterns but in one or two cases these also resembled very closely the normal talc pattern.

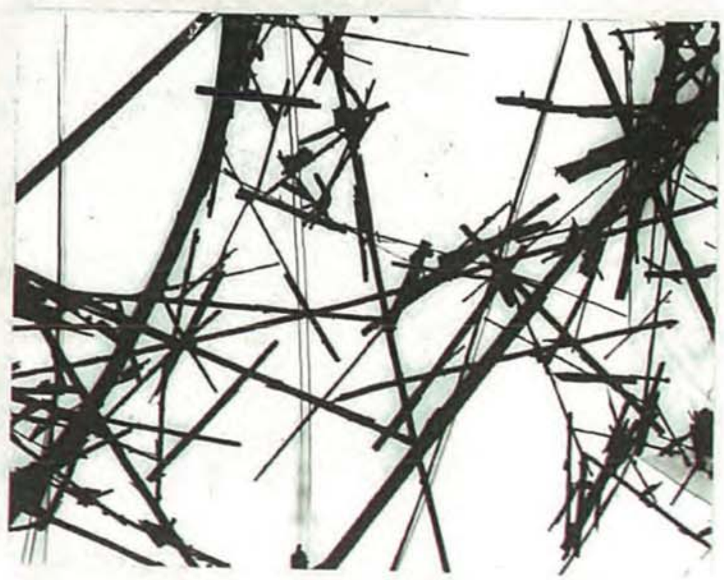
Examples of Commercial Amphibole and Chrysotile asbestos particles together with typical selected area electron diffraction patterns.

Chrysotile asbestos particles x 3000

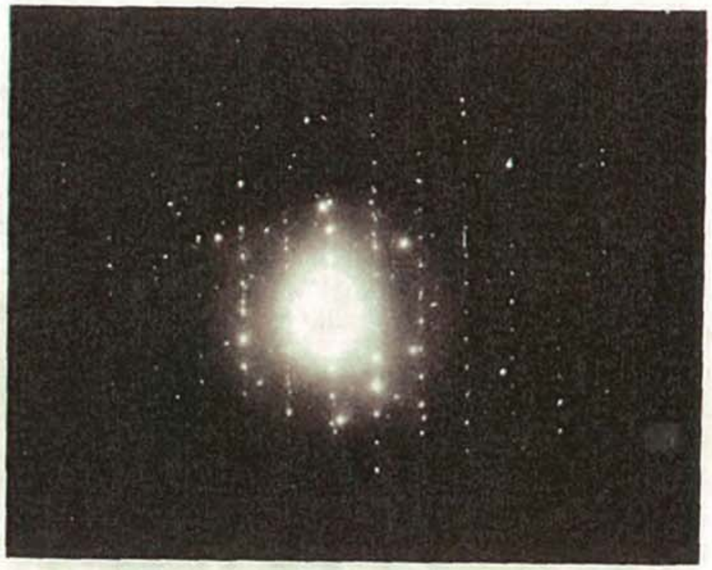
Anthophyllite asbestos particles x 3000



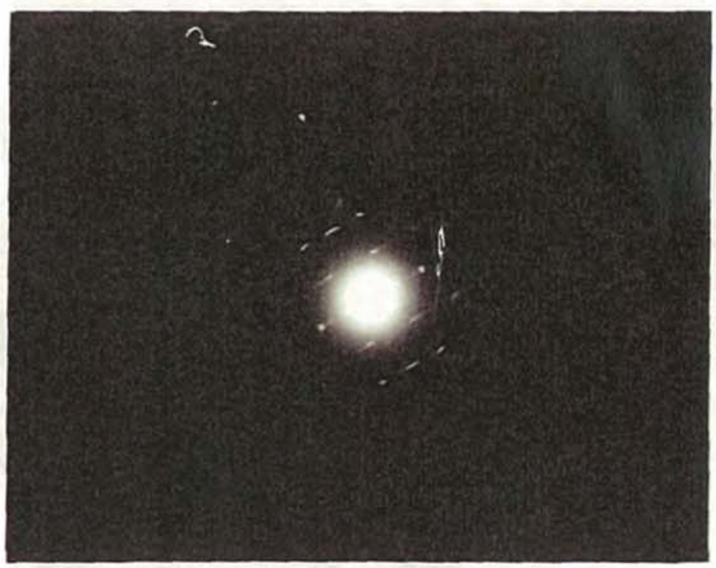
Amosite asbestos particles x 3000



Crocidolite asbestos particles x 3000



Amphibole asbestos selected area
electron diffraction pattern.



Chrysotile asbestos selected area
electron diffraction pattern.

Electron micrographs of particles produced from specimens which have been classified as rock types.

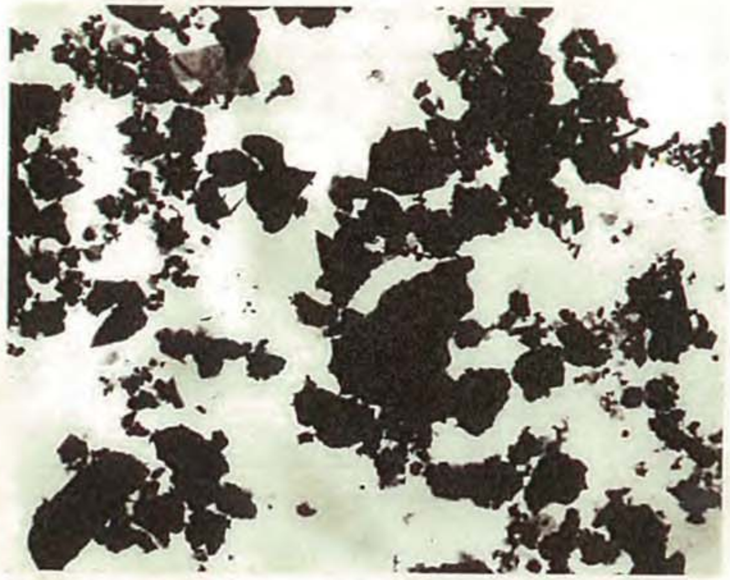


Fig. 1. Specimen I_{13} seam inclusion showing passage into talc x 3000. The particles are mainly compact and electron dense. A few flakes, no fibres present.

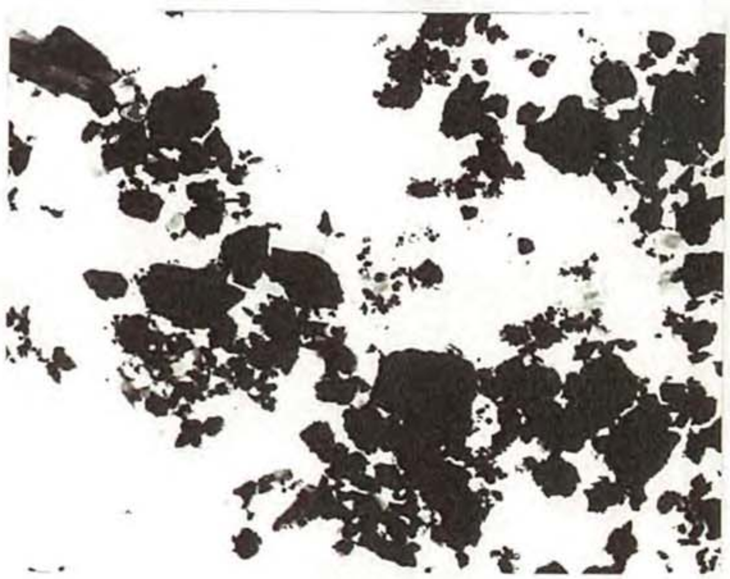


Fig. 2. Specimen I_{15}. Talc footwall contact. x 3000. Compact particles with a few small flakes. No fibres present.

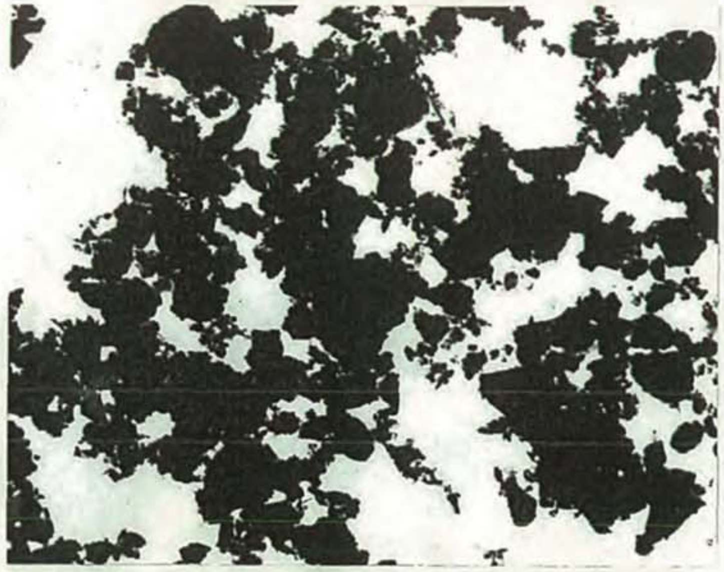


Fig. 3. Specimen I_{16}. Lithological inclusion from Face 1. x 3000. Compact electron dense particles. No fibres present.

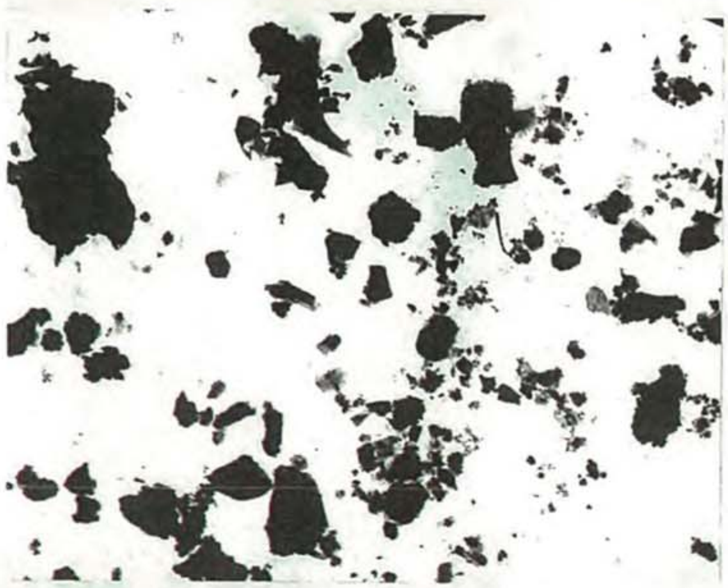


Fig. 4. Specimen I_{17}. Footwall rock sample, x 3000. Mainly compact particles produced with a few plate like forms.

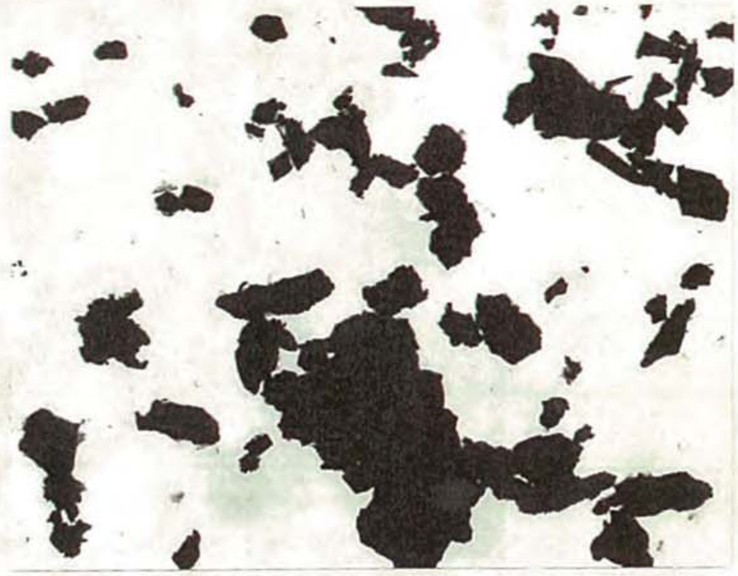


Fig. 5. Specimen I23. Black gneiss, 2ft below talc seam. x 3000. Compact electron dense particles produced.

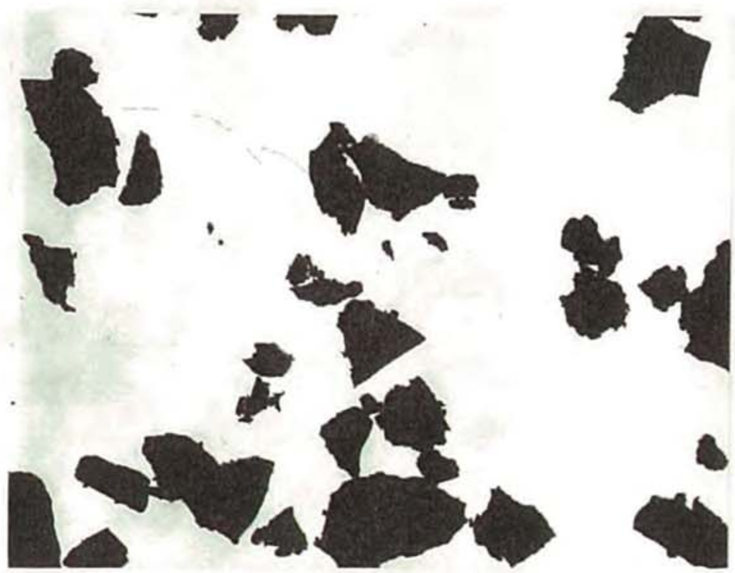


Fig. 6. Specimen I25. Footwall limestone. x 3000. Compact electron dense particles.

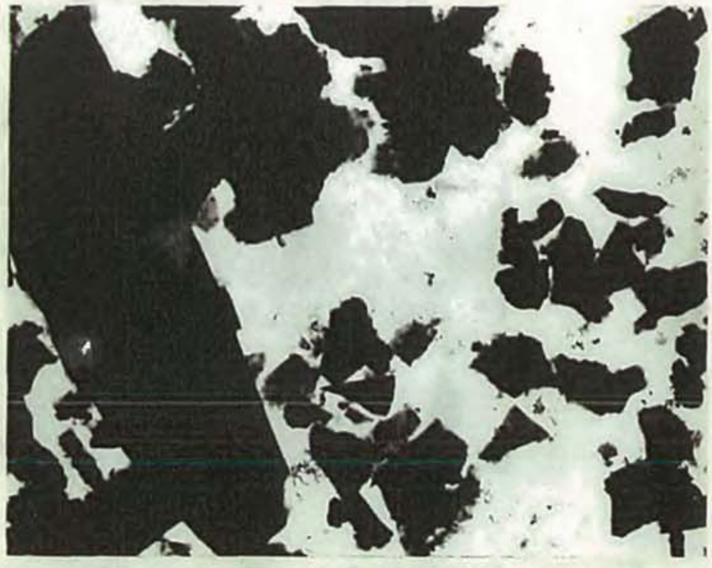


Fig. 7. Specimen I27. Lithological inclusion face 1. x 3000. Platey electron dense particles. No fibres.

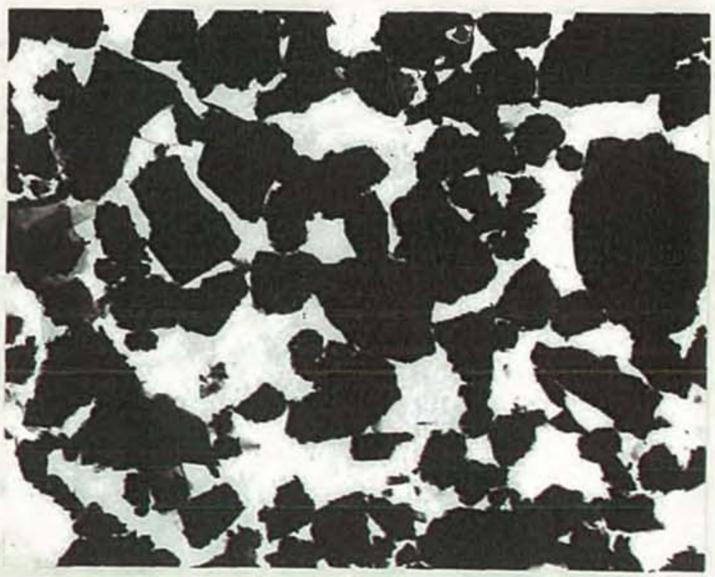


Fig. 8. Specimen I29. Sample 6 Footwall. x 3000 Compact electron dense particles with a few plate-like forms.

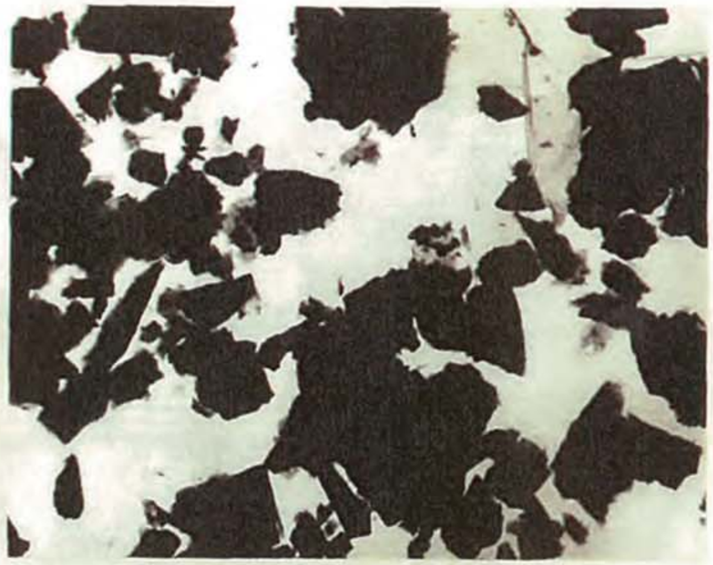


Fig. 9. Specimen I31. Black inclusion face 1. x 3000
A mixture of plate-like and compact forms mainly electron dense in character.

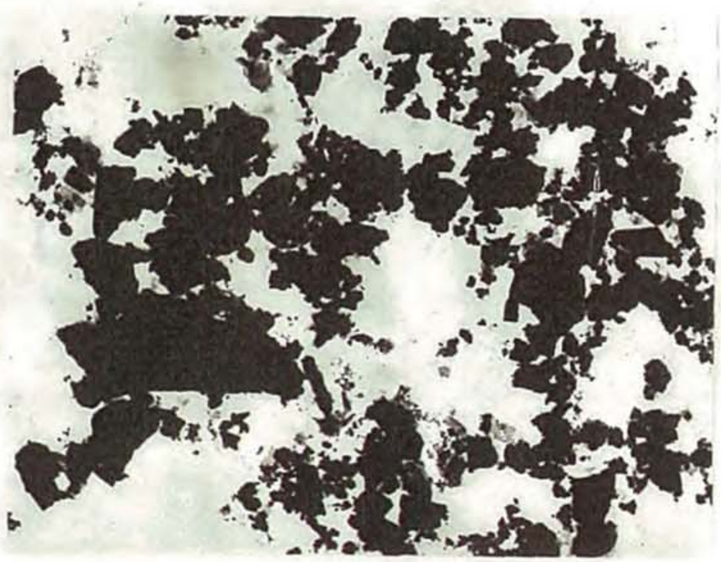


Fig.10. Specimen I34. Marble from tunnel wall. x 3000
Mainly compact electron dense particles with a few plate-like forms.

Electron micrographs of particles produced from those specimens mainly composed of carbonate minerals.

Fig. 1. Specimen I_{11}. Carbonate inclusion with some talc. x 3000. Particles consist of a mixture of compact and plate-like forms.

Fig. 2. Specimen I_{14}. Inclusion in talc seam Face 4, middle of seam. x 3000. Granular particles with plate-like types and lath-like forms.

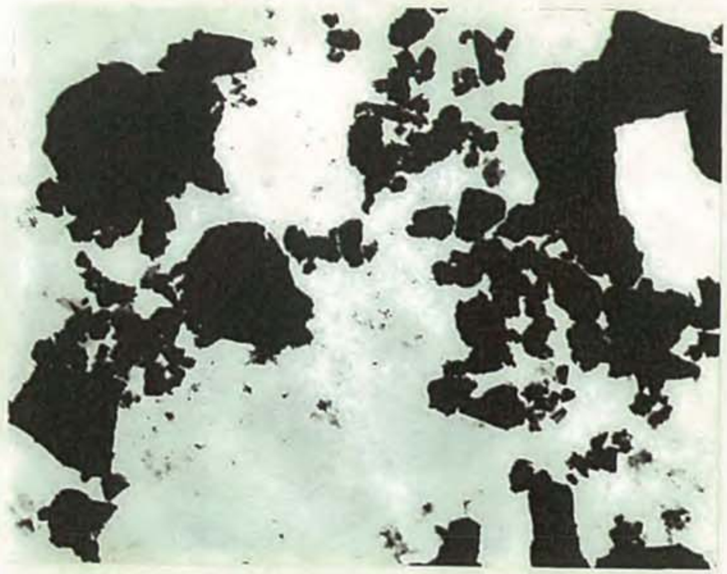


Fig. 3. Specimen I_{18}. Carbonate/talc sample, x 3000. Particles compact and electron dense. A few plate-like forms.

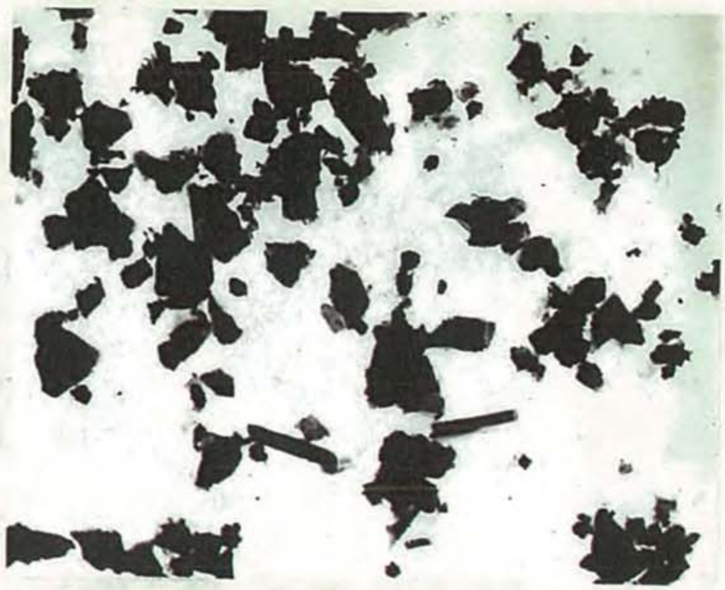


Fig. 4. Specimen I_{21}. Inclusion from Face 2. x 3000. This specimen produced plate-like and compact particles with some lath-like forms.

Fig. 5. Specimen I35. Massive carbonate from rear end of working, x 3000. Compact electron dense particles with some plate-like talc particles.

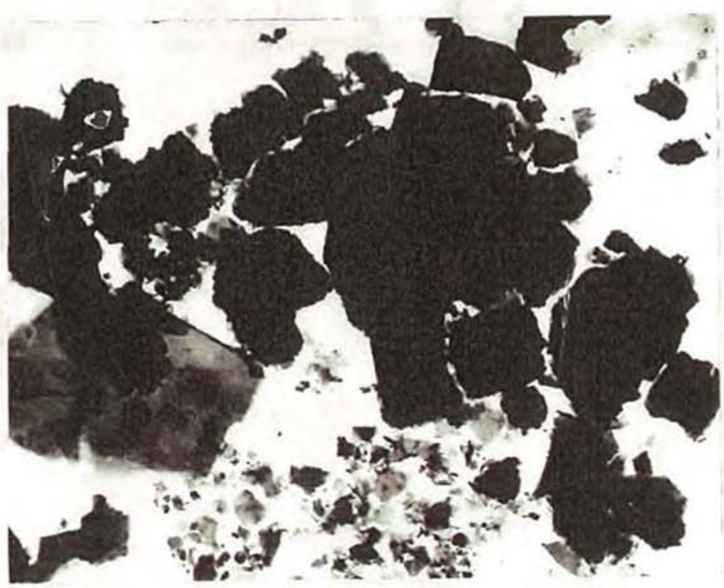


Fig. 6. Specimen I37. Carbonate in talc inclusion x 3000. Compact particles together with some plate-like forms and rolled talc sheets.

Electron Micrographs of specimens of talc with carbonate and other mineral inclusions.

Fig. 1. Specimen I3. Coloured talc (Green) x 3000. Particles plate-like. Few fibres, rolled sheets and shords.

Fig. 2. Specimen I5. General ore, x 3000. Plate-like particles together with short lath-like particles, also a typical example of textile type fibre.

Fig. 3. Specimen Ig. Massive talc, x 3000. Plate-like particles with a few lath- forms also typical textile type long fibre.

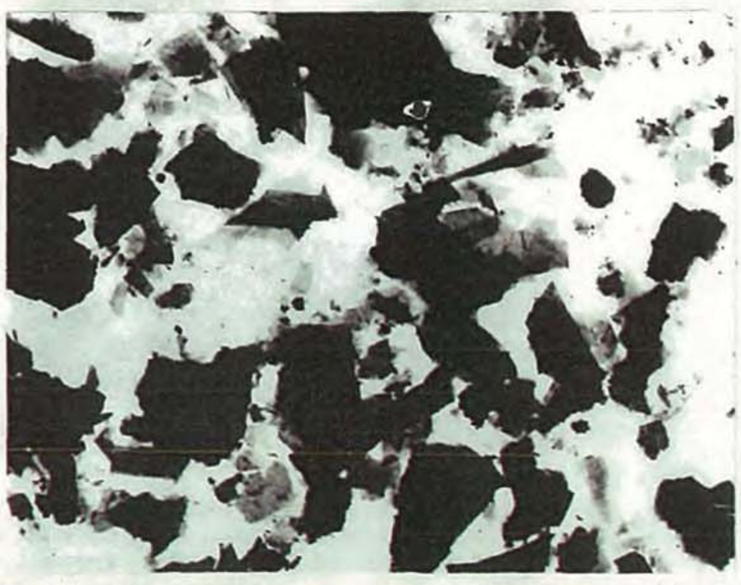


Fig. 4. Specimen Ig. Grey talc First Face, x 3000. Practic ally all plate-like with a few lath forms.

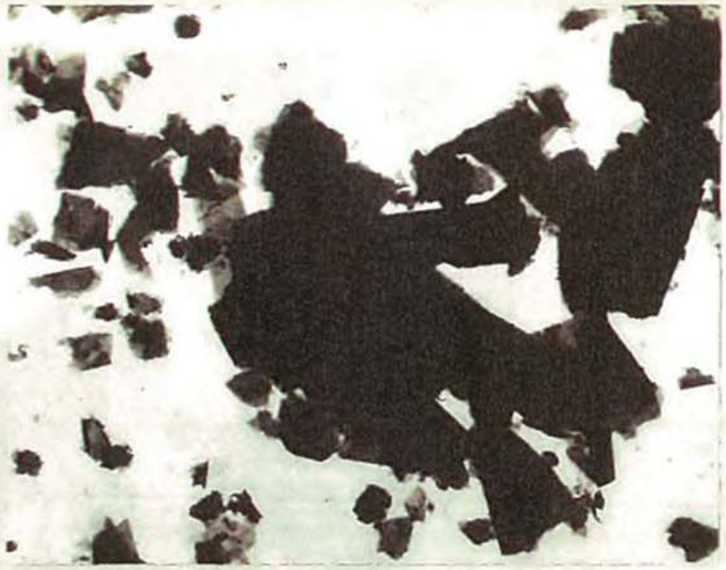


Fig. 5. Specimen I_{10}. Granular talc, x 3000. All plate-like particles.

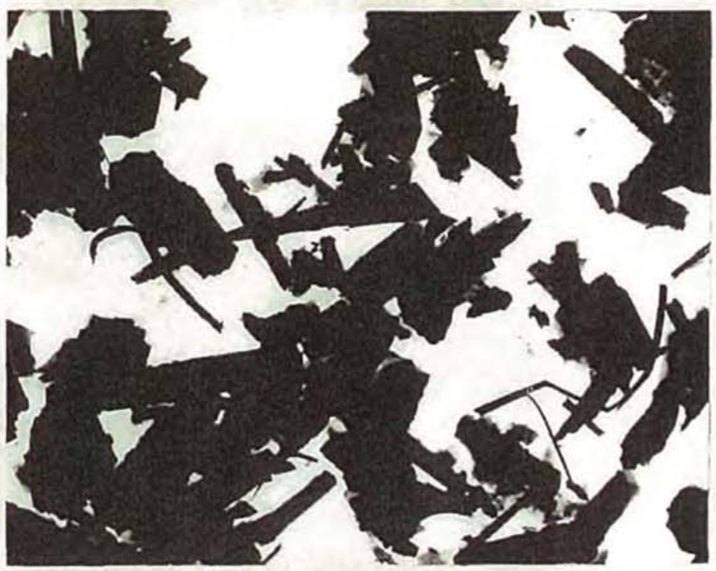


Fig. 6. Specimen I_{24}. Talc next to carbonate inclusion, x 3000. This specimen was found to contain a large number of lath-like particles, as can be seen from the micrograph above. No diffraction pattern corresponding with an amphibole fibre was obtained from a selection of the elongated particles.

Fig. 7. Specimen I26. Coloured talc inclusions, x 3000. The particles produced from the various coloured inclusions in the talc were found to be mainly plate-like with a few lath forms.

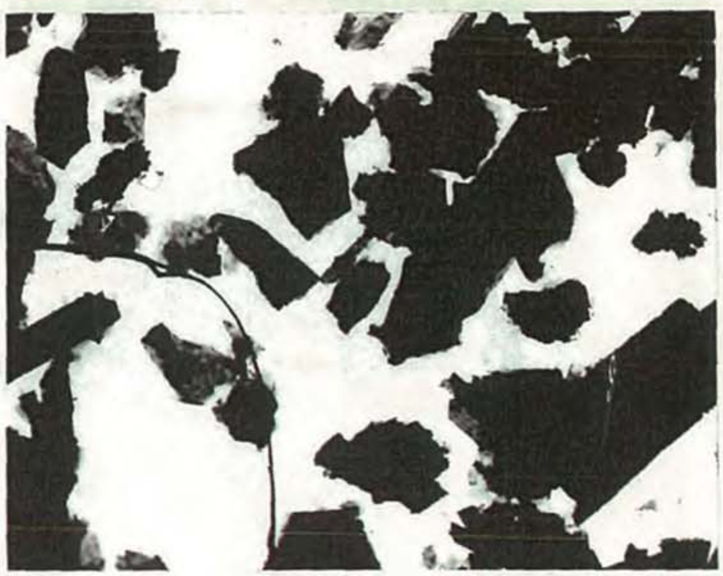


Fig. 8. Specimen I28. Talc/Quartz specimen, x 3000. Particles from this specimen were mainly plate-like but accompanied by more compact opaque particles. A few textile type fibres were observed.

Fig. 9. Specimen I32. Face 2 inclusion from base of talc seam, x 3000. The specimen produced a mixture of irregular particles varying from compact to plate-like in form with a few lath like particles.

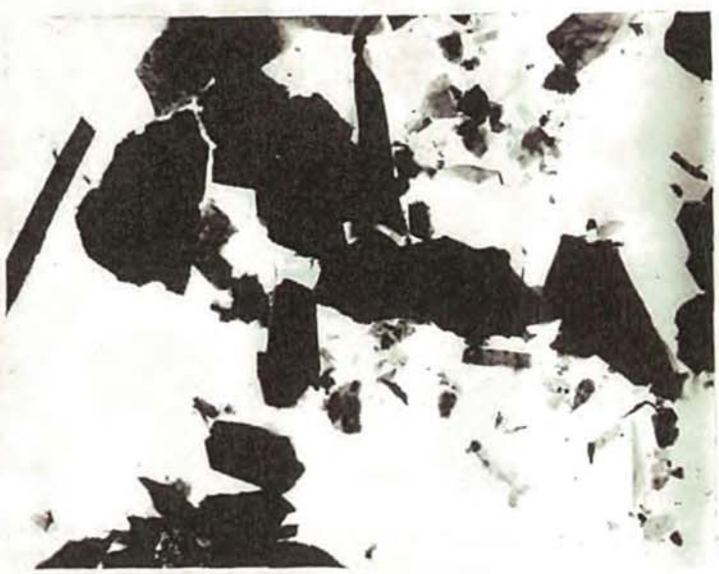


Fig.10. Specimen I33. Talc from lower left end of working x 3000. Particles mainly plate-like with some lath forms.

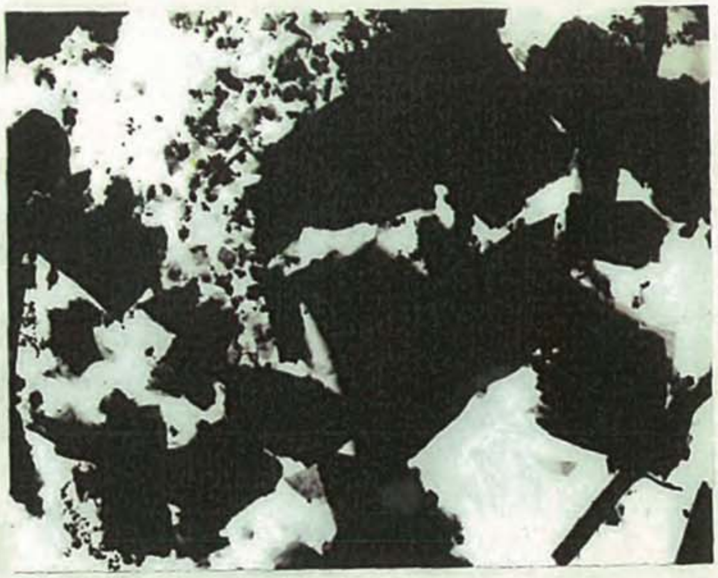


Fig. 11. Specimen I38. Pyrite/Talc specimen, x 3000. Plate-like particles with some rolled tubes of talc.

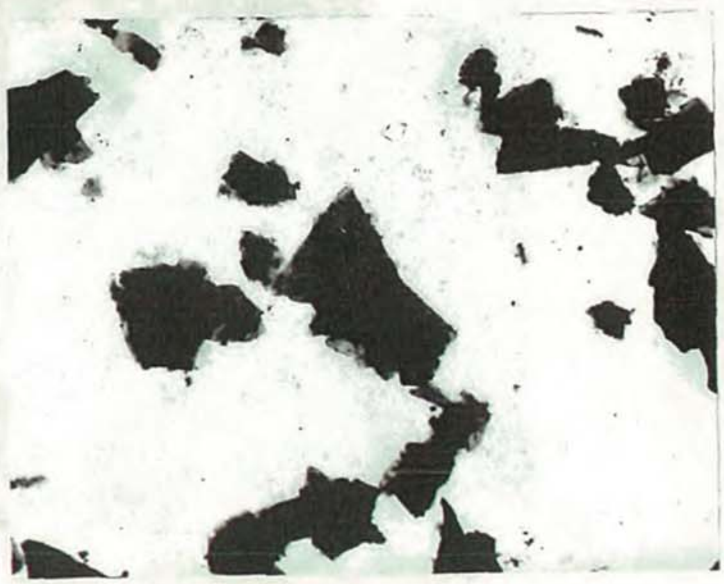


Fig. 12. Specimen I39. 5" - 0 coloured pieces from the crusher, x 3000. These various coloured talc pieces produced only plate-like particles.

Fig. 13 Specimen I41. Face 2, good talc specimen x 3000. Plate-like particles together with rolled talc sheets lath forms and textile type fibres.

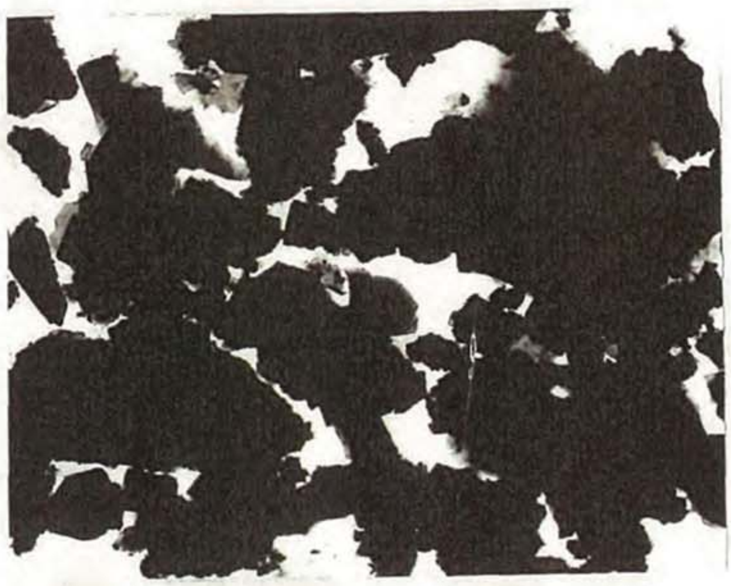


Fig. 14. Specimen I42. Face 1, green coloured talc, x 3000. This coloured specimen produced plate-like particles which were rather more electron dense.

Fig. 15. Specimen I43. Face 10. Fibrous looking hand specimen, x 3000. This sample was found to be practically all plate-like in form.

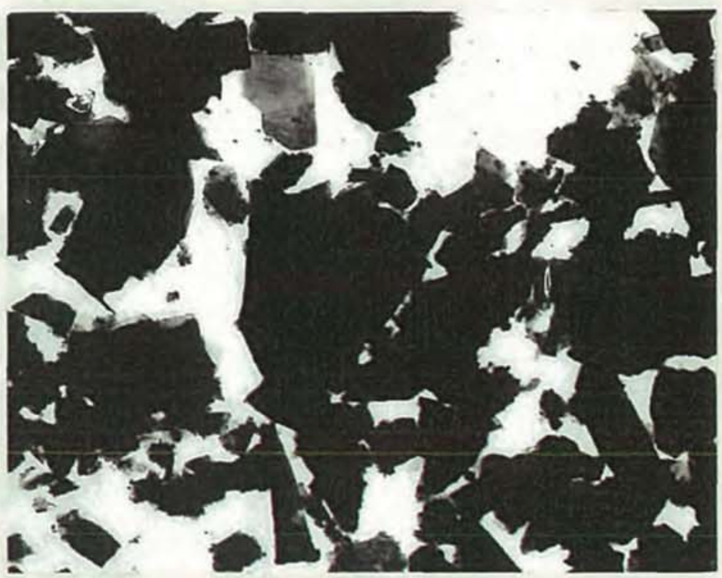


Fig. 16. Specimen I44. Face 1. Pure talc sample, x3000. Plate-like particles with some lath-like forms.

Fig. 17. Specimen I45. Face 1. Good talc specimen, x 3000. A mixture of plate-like particles and fibrous forms, including rolled tubes and textile type fibres.

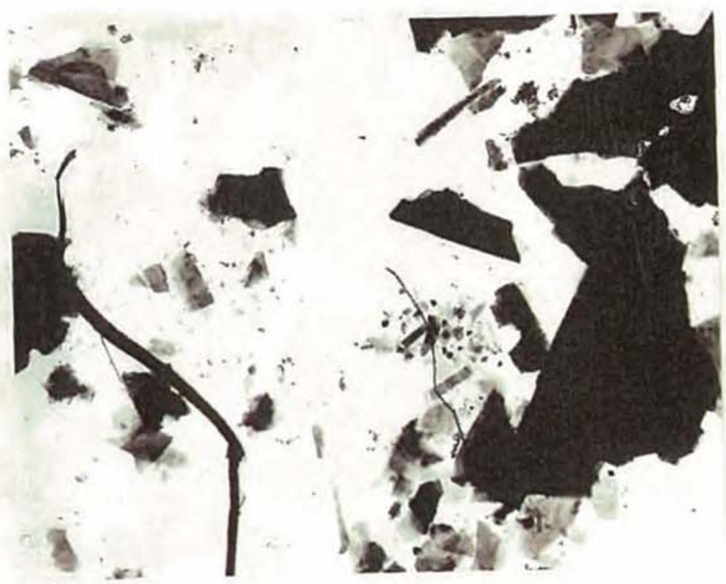
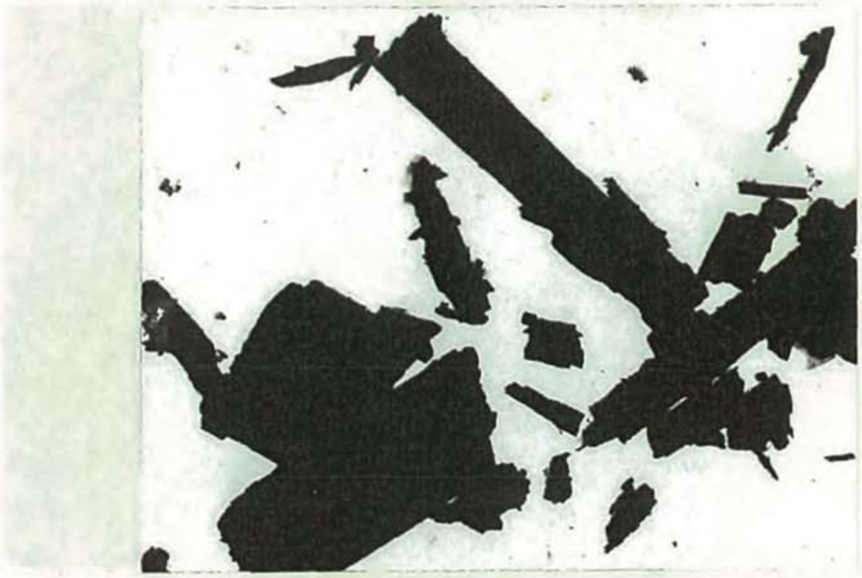


Fig. 18. Specimen I48. Face 3. Coloured specimen x 3000. Plate-like particles with shards and lath like forms, together with a typical textile form, which can be seen to have a sheet-like form.

Electron Micrographs of particles produced from those specimens containing amphibole mineral and also from the amphibole mineral itself.

Fig. 1. Specimen I19. Tremolite/carbonate talc sample x 3000. Compact particles, a few lath forms present.

Fig. 2. Specimen I20. Amphibole sample from Guiana level 1212. x 3000. Compact particles with numerous lath forms.



Figs. 3 and 4

Particles produced from single crystals of tremolite extracted from specimens I_{19} and I_{20}. x 3000. Very few fibrous particles were produced when this specimen was crushed. Those that were fibrous in nature were thick and stubby in character, less than 50% of the particles were elongated in shape.

Figs. 5 and 6

Selected area electron diffraction patterns obtained from amphibole particles found in specimens I_{19} and I_{20}.

Fig. 7. Typical selected area diffraction pattern obtained from talc plates.

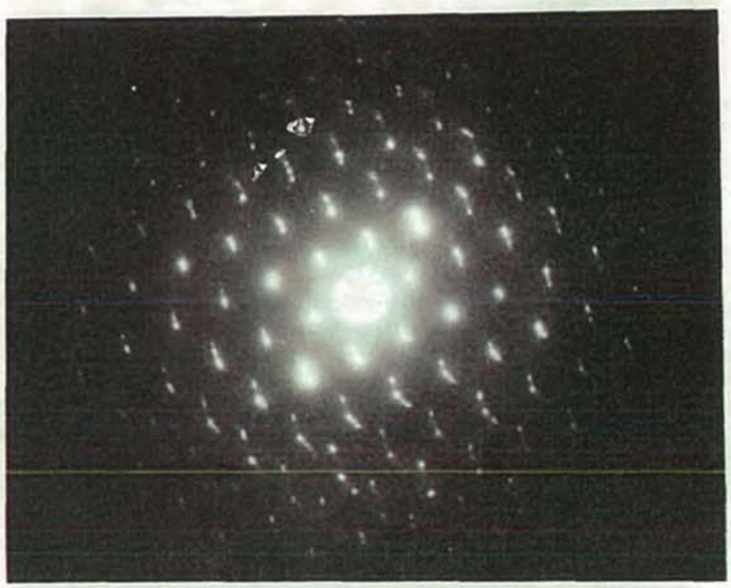


Fig. 8. Selected area diffraction pattern obtained from a typical textile type fibre showing features of a rotated or coiled structure.

X-RAY ANALYSIS OF ITALIAN MINE SAMPLES

Introduction

This report concerns the X-ray powder analysis of the Italian mine samples. The samples were classified into three categories according to their chemical and physical properties:

(i) 'Rock' Type
(ii) 'Talc' Type
(iii) 'Carbonate' Type

All the samples were prepared by similar means and the procedure for obtaining the X-ray powder patterns was standardised.

From these powder photographs, several were chosen which clearly showed distinct mineral phases. These were used as standards for this group of samples. These standard patterns were compared against the ASTM index and this comparison illustrates the need to prepare standards for a particular locality from specimens at that locality.

The samples were compared with these standards by computer methods and visually and the results and discrepancies between the methods of comparison noted.

LIST OF SAMPLES

See Table 1

SAMPLE PREPARATION

The samples were received mainly as large rocks and were labelled according to their appearance and location in the mire.

With the larger samples a section was cut from the middle to be a representative sample, for the smaller samples as many pieces as possible were crushed to form the representative sample.

These samples were then roughly broken up and placed in a 'Tema' disc mill and ground for 5 mins. until all the sample was below approx. 100 mesh. These powders were stored in clean plastic bags. The samples, when required for X-ray analysis, were further ground (to less than 3000 mesh) in a small agate ball mill and then sieved through a 350 mesh screen and stored in plastic bags.

The grinding mills and other apparatus used were thoroughly cleaned between samples and during the grinding care was taken to obtain a good representative sample.

X-RAY ANALYSIS

All the samples were analysed using a Debye-Scherrer camera mounted on a Raymax RX 3-D X-ray generator. A copper X-ray tube was used with nickel filters (0.02 mm thick) and the power rating of the tube set at 36 kV and 22mA.

The apparatus was carefully aligned and checked before mounting a sample. All the samples had the same exposure time of 8 hrs.

The samples were loaded into 0.5 mm diameter Lindemann glass tubes to be mounted in the Debye-Scherrer cameras. In the cameras Ilford Industrial 'G' X-ray film was used. The film was processed using Kodak DX-80 developer and Ilford Hypain fixer. The films were developed for 5 minutes using a 1:4 dilution for the developer and fixed for 2 minutes. The films were then washed in running water for 30 minutes and allowed to dry naturally. The X-ray films were then measured.

Using an illuminated screen and the line-spacings calculated, taking into account film shrinkage, from these line spacings the bragg angle and 'd' spacings can be calculated.

STANDARD PATTERNS

When all the samples X-ray photographs had been measured and the 'd' spacings calculated, they were visually inspected to find the film showing samples with pure mineral phases. These patterns were then taken as standards.

The samples were then broken up and the different mineral phases were sorted by hand to attempt to find a purer standard. These samples were then crushed in a similar way to the samples crushed beforehand. For X-ray analysis they were placed in 0.2 mm diameter tubes and given a 12 hr exposure. This method was used to give finer lines on the X-ray photograph and the larger exposure was to try and detect as many impurities as possible.

The 'd' spacings of the standards were compared with the A.S.T.M. index and also with themselves. They were compared with themselves to check that all the Talc and Chlorite standards matched each other and were similar in intensity.

Several standards were prepared containing the same mineral. This was because the 'd' spacings of the mineral varied slightly from sample to sample and especially with chlorite, depending on its composition the major reflections varied between 13.5Å and 15.0Å. This was mainly due to varying iron content and this can easily be seen on the X-ray films as it causes fluorescence with copper radiation and blackens the X-ray film generally.

RESULTS

For the analysis of the results the samples have been divided into five sections:

(i) standard patterns
(ii) sample patterns (rock type)
(iii) sample patterns (carbonate type)
(iv) sample patterns (talc type)
(v) batch sample patterns (includes old powders and shipments).

Two methods were used to find the mineral present in the sample. One method uses a computer program to detect the mineral.

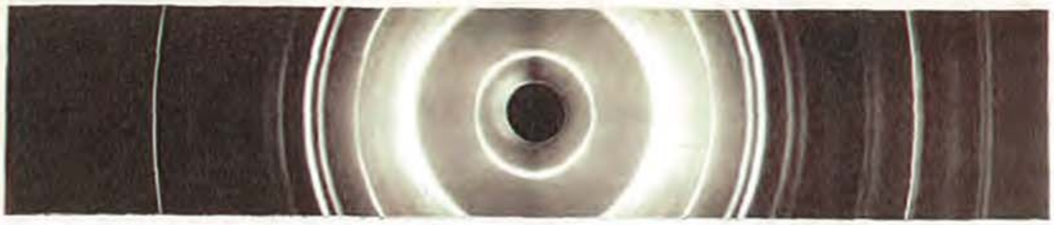
In this method the bragg angles of samples were compared with the bragg angles of the standard and the number of lines fitted printed out. A print out was also obtained of all the standards which fitted a particular line to find all the possible minerals present and to see which lines were common to several standards.

As this procedure is quite long, the lines in the sample were first sorted into order of decreasing intensity and then the three most intense lines of the sample compared with the standards. If all three lines failed to match it was considered that that standard was not present and so the program deleted that standard from the comparison. At the end of the program the list of the standards was printed with the percentage of lines fitted to the sample noted.

The obvious disadvantage of this comparison was that the program could take no account of the relative intensities of the lines and so a visual method was used to find which was the major mineral phase. The computer program usually found the mineral phases present in the samples but could not place them in the correct order.

Patterns used as standards from the Italian mine samples and their comparison with A.S.T.M. data and against themselves.

SAMPLE SIP 1 TALC



Comparison against A.S.T.M. index: 1 line unmatched, 1.1145 Å

Patterns not included: 6-263 Muscovite -2M1, 7-25 Muscovite (1M), 7-32 Muscovite (2M1), 7-76 Ripidolite (Chlorite), 7-78 Thuringite (Chlorite), 7-166 Bavalite (Chlorite), 10-183 Peninnite Chlorite, 11-78 Dolomite, B and T Quartz.

Most probable minerals present: Talc Muscovite Calcite

Comparison against Italian Standards

Patterns not included: Chlorite (I42), Chlorite (I4), Muscovite (I35), Magnesite (I6), Tremolite (I19/I20), Dolomite.

Most probable minerals present: Talc

Visual comparison	Minerals detected
Talc, Calcite	Talc, Calcite

SAMPLE SIP 2 TALC

Comparison against A.S.T.M. index: 2 lines unmatched, 1.1159Å 1.1353Å

Patterns not included: 7-76 Ripodolite (Chlorite), 7-78 Thuringite (Chlorite), 7-166 Bavalite (Chlorite).

Most probable minerals present: Talc, Muscovite, Calcite

Comparison against Italian Standards

Patterns not included: Chlorite (I42), Chlorite (I4), Tremolite (I19/I20).

Most probable minerals present: Talc, Muscovite, Magnesite.

Visual Comparison	Minerals Detected
Talc, Chlorite, Magnesite	Talc, Chlorite, Magnestie

SAMPLE SIP 3 CHLORITE

Comparison against A.S.T.M. index: 2 lines unmatched, 1.1739Å, 1.29Å

Patterns not included: 6-263 Muscovite -2M1, 7-25 Muscovite (IM) 7-32 Muscovite (2M1), 7-79 Forsterite (Olivine), 8-479 Magnesite

Most probable minerals present: Chlorite, Talc

Comparison against Italian Saandards

Patterns not included: Muscovite (I35), Tremolite (I19 and I20)

Most probable minerals present: Chlorite, Talc.

Visual Comparison	Minerals Present
Chlorite, Talc	Chlorite, Talc

SAMPLE SIP 4 CHLORITE

Comparison against A.S.T.M. index: 3 lines unmatched 1.1741Å, 1.1318Å, 1.0984Å.

Patterns not included: 6-263 Muscovite -2M1, 7-32 Muscovite (2M1), 8-479 Magnesite, 11-78 Dolomite, 13-437 Boric Acid.

Most probable minerals present: Chlorite, Talc

Comparison against Italian Standards

Patterns not included: Calcite (I34), Magnesite (I37), Muscovite (I35), Tremolite (I19/I20), Dolomite.

Most probable mineral present: Chlorite, Talc

Visual Comparison	Minerals Present
Chlorite, Talc	Chlorite, Talc

SAMPLE SIP 5 TALC

Comparison against A.S.T.M. index:

Patterns not included: 5-586 Calcite, 7-25 Muscovite (IM), 7-77 Sheridanite (Chlorite), 7-79 Forsterite (Olivine), 7-166 Bavalite (Chlorite).

Most probable minerals present: Talc, Muscovite, Chlorite

Comparison against Italian Standards

Patterns not included: Chlorite (I42), Chlorite (I4), Magnesite (I6), Tremolite (I19/I20).

Most probable minerals present: Talc

Visual comparison	Minerals Present
Talc, Chlorite	Talc, Chlorite

SAMPLE SIP 6 MUSCOVITE

Comparison against A.S.T.M. index: 3 lines unmatched, 1.7999Å, 1.3721Å, 1.2741Å.

Patterns not included: 3-881 Talc, 7-79 Forsterite (Olivine), 7-166 Bavalite (Chlorite), 7-183 Penninite (CHlorite), 8-479 Magnesite, 11-78 Dolomite, 19-770 Talc.

Most probable minerals present: Muscovite, Chlorite

Comparison against Italian Standards

Patterns not included: Magnesite (I37), Tremolite (I19 and I20), Dolomite

Most probable minerals present: Muscovite, Talc

Visual Comparison	Mineral Present
Muscovite, Calcite	Muscovite, Calcite

SAMPLE SIP 7 MAGNESITE

Comparison against A.S.T.M. Index: 1 line unmatched 1.1092Å

Patterns not included: 5-586 Calcite, 6-263 Muscovite -2M1, 7-25 Muscovite (IM), 7-32 Muscovite (2M1), 7-160 Chlorite (Kotshubeite), 7-76 Ripodolite (Chlorite), 7-78 Thuringite (Chlorite), 7-166 Bavalite (Chlorite), 10-183 Penninite Chlorite, 13-437 Tremolite.

Most probable minerals present: Magnesite, Dolomite, Talc

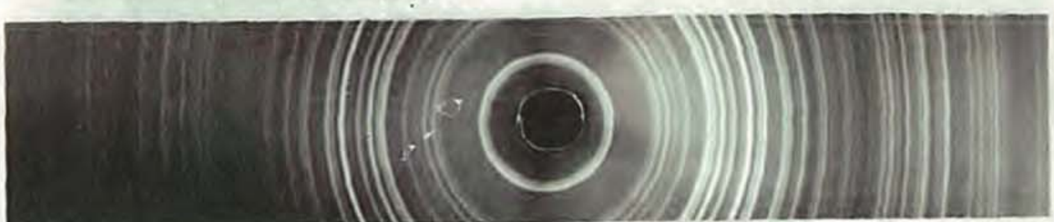
Comparison against Italian Standards

Patterns not included: Calcite (I34), Chlorite (I4) Muscovite (I35), Tremolite (I19/I20).

Most probable minerals present: Magnesite, Dolomite, Talc

Visual Comparison	Minerals Present
Magnesite, Talc	Talc, Magnesite.

SAMPLE SIP 8 TREMOLITE



Comparison against A.S.T.M. Index: 1 line unmatched 1.1118Å

Patterns not included: 6-263 Muscovite -2M1, 7-25 Muscovite (IM), 7-32 Muscovite (2M1), 7-42 Muscovite (3T), 7-79 Forsterite (Olivine).

Most probable minerals present: Tremolite, Talc, Calcite

Comparison against Italian Standards

Patterns not included: Magnesite (I37), Chlorite (I4), Muscovite (I35).

Most probable minerals present: Tremolite, Talc, Calcite

Visual Comparison	Minerals Present
Tremolite, Talc	Tremolite, Talc

SAMPLE SIP 9 DOLOMITE

Comparison against A.S.T.M. Index: 1 line unmatched 1.1094Å

Patterns not included: 3-881 Talc, 6-263 Muscovite -2M1, 7-25 Muscovite (IM), 7-32 Muscovite (2M1), 19-814 Muscovite 2M1 (Vanadian), 7-160 Chlorite (Kotschubeite), 7-79 Forsterite (Olivine), 13-437 Tremolite, 19-770 Talc.

Most probable minerals present: Dolomite, Muscovite

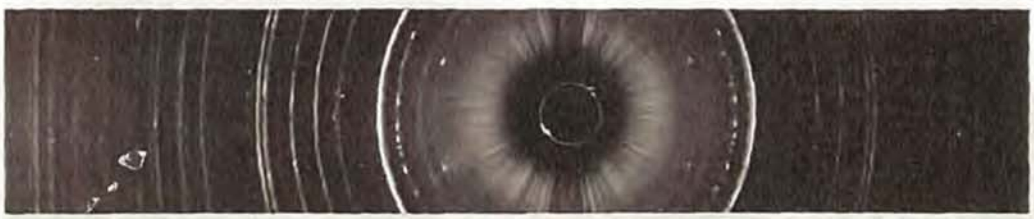
Comparison against Italian Standards

Patterns not included: Magnesite (I37), Chlorite (I4) Tremolite (I19/I20).

Most probable minerals present: Dolomite, Talc

Visual Comparison	Minerals Present
Dolomite, Muscovite, Calcite	Dolomite, Muscovite, Calcite

SAMPLE SIP 10 CALCITE



Comparison against A.S.T.M. Index: 3 unmatched lines 1.2095Å, 1.1098Å, 1.0926Å

Patterns not included: 7-160 Chlorite (Kotschubeite), 7-79 Forsterite (Olivine), 13-437 Tremolite.

Most probable minerls present: Calcite, Muscovite

Comparison against Italian Standards

Patterns not included: Magnesite (I6), Tremolite (I19-I20).

Most probable minerals present: Calcite, Muscovite

Visual Comparison	Minerals Present
Calcite	Calcite, Muscovite

SAMPLE SIP 11 MAGNESITE

Comparison against A.S.T.M. Index: 1 unmatched line 1.1085Å

Patterns not included: 5-586 Calcite, 7-25 Muscovite (IM), 7-160 Chlorite (Kotschubeite), 7-76 Ripidolite (Chlorite), 7-78 Thuringite (Chlorite), 7-166 Bavalite (Chlorite), 10-183 Penninite Chlorite, B & T Quartz.

Most probable minerals present: Magnesite, Dolomite, Talc

Comparison against the Italian Standards

Patterns not included: Calcite (I34), Chlorite (I4), Muscovite (I35).

Most probable minerals present: Magnesite, Dolomite, Talc

Visual Comparison	Minerals Present
Magnesite, Dolomite, Talc	Magnesite, Talc, Dolomite

Examples of Patterns Obtained from
Rock Type Specimens and Their
Major Mineral Content from X-Ray
Comparison.

SAMPLE I1 TALC FROM FOOTWALL CONTACT

Comparison

Patterns not included: Magnesite (I37), Tremolite (I19/I20).

Most probable minerals present: Chlorite, Muscovite, Talc, Dolomite.

Visual Comparison: Talc Chlorite, Calcite

Minerals Present: Talc Chlorite, Calcite.

SAMPLE I7 MICA SCHIST

Comparison

Patterns not included: Magnesite (I37), Talc (I46), Tremolite (I19/I20).

Most probable minerals present: Muscovite, Talc, Quartz

Visual Comparison: Muscovite, Talc, Quartz

Minerals Present:

SAMPLE I12 FOOTWALL SAMPLE? AMPHIBOLITE

Comparison: 3 lines unmatched. 6.4653Å 1.2819Å 1.225Å

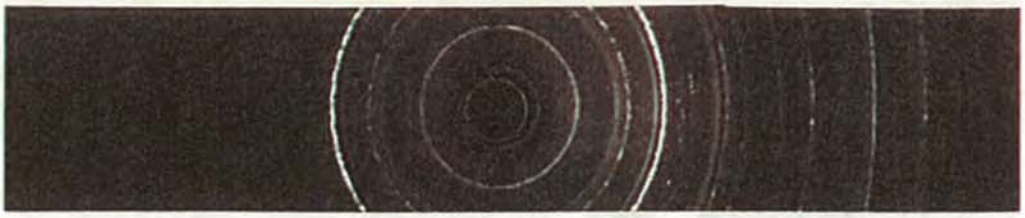
Patterns not included: Calcite (I34), Magnesite (I37), Talc (I46), Talc (I5), Tremolite (I19/I20).

Most probable minerals present: Muscovite, Dolomite, Quartz.

Visual Comparison: Muscovite, Chlorite, Quartz

Minerals Present:

SAMPLE I13 INCLUSION SHOWING PASSAGE INTO TALC BOTTOM TRANSIT



Comparison: 1 unmatched line 1.1541Å

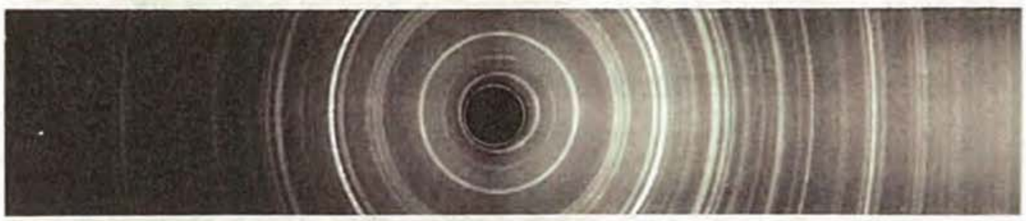
Patterns not included: Magnesite (I37), Muscovite (I35), Tremolite (I19/I20), Dolomite

Most probable minerals present: Chlorite, Talc, Quartz

Visual Comparison: Chlorite, Muscovite, Quartz

Minerals Present: Chlorite, Muscovite, quartz

SAMPLE I15 TALC-FOOTWALL CONTACT



Comparison:

Patterns not included: Magnesite (I37), Tremolite (I19/I20).

Most probable minerals present: Chlorite, Talc, Muscovite, Quartz.

Visual Comparison: Chlorite, Talc, Quartz

Minerals Present: Chlorite, Talc, Quartz

SAMPLE I16 FACE 1 INCLUSION BELOW SEAM

Comparison

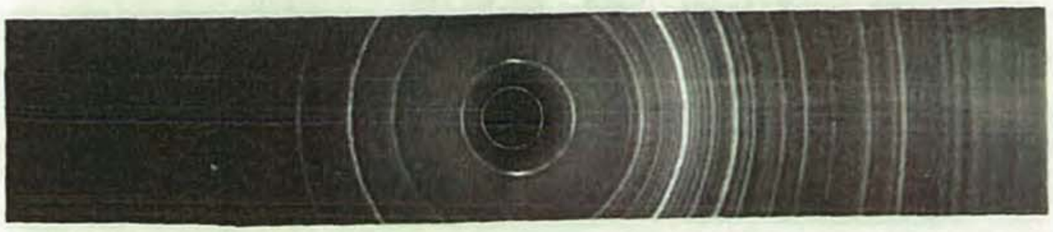
Patterns not included: Talc (I45), Tremolite (I19/I20) Dolomite

Most probable minerals present: Muscovite, Chlorite, Calcite, Quartz

Visual Comparison: Chlorite, Muscovite, Calcite, Quartz

Minerals Present: Chlorite, Muscovite, Calcite, Quartz

SAMPLE I17 FOOTWALL ROCK SAMPLE



Comparison: 2 unmatched lines 6.6957Å, 1.6305Å

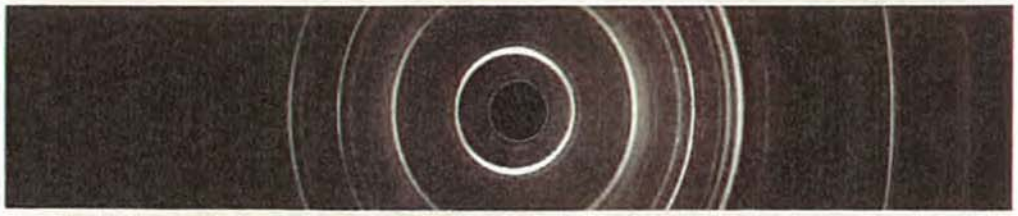
Patterns not included: Talc (I46), Chlorite (I42), Muscovite (I35), Magnesite (I6), Tremolite (I19/I20), Dolomite.

Most probable minerals present: Calcite, Talc, Quartz

Visual Comparison: Calcite, Talc, Quartz

Minerals Present: Calcite, Talc, Quartz

SAMPLE I20 AMPHIBOLE SAMPLE FROM GUIANA LEVEL 1212



Comparison: 1 unmatched line 1.6309Å

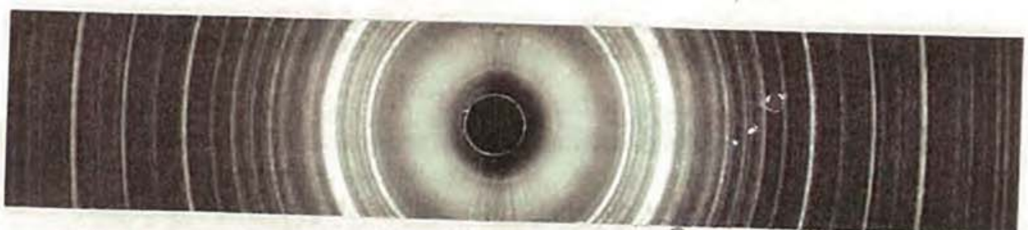
Patterns not included: Chlorite (I42), Chlorite (I4), Muscovite (I35), Magnesite (I6), Dolomite.

Most probable minerals present: Talc, Tremolite, Calcite, Magnesite.

Visual Comparison: Talc, Tremolite, Chlorite

Minerals Present: Talc, Chlorite, Tremolite

SAMPLE I23 BLACK GNEISS



Comparison: 5 unmatched lines 6.3586Å, 1.449Å, 1.2278Å, 1.2121Å, 1.1520Å.

Patterns not included: Calcite (I34), Tremolite (I19/I20)

Most probable minerals present: Muscovite, Talc, Magnesite, Quartz

Visual Comparison: Muscovite, Magnesite, Quartz

Minerals Present: Muscovite, Magnesite, Quartz

SAMPLE I25 LIMESTONE FOOTWALL

Comparison

Patterns not included: Calcite (I34), Tremolite (I19/I20).

Most probable minerals present: Talc, Chlorite, Quartz

Visual Comparison: Talc, Magnesite, Quartz

Minerals Present: Talc, Magnesite, Quartz

SAMPLE I27 LITHOLOGICAL INCLUSION

Comparison

Patterns not included: Chlorite (I42), Chlorite (I4), Tremolite (I19/I20), Magnesite (I6), Dolomite

Most probable minerals present: Talc, Calcite, Quartz

Visual Comparison: Talc, Calcite, Quartz

Minerals Present: Talc, Calcite, Quartz

SAMPLE I29 SAMPLE 6 FOOTWALL

Comparison: 2 unmatched lines 1.1526Å, 6.3031Å

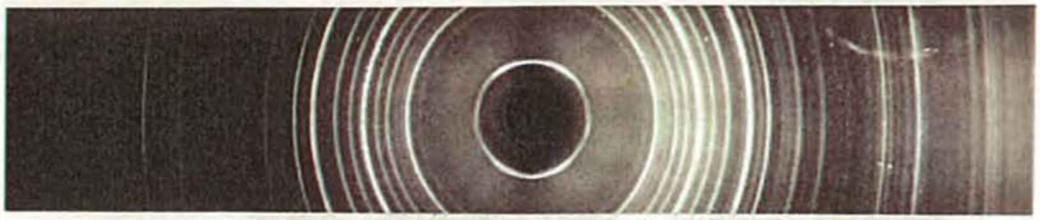
Patterns not included: Calcite (I34), Magnesite (I37), Chlorite (I4), Talc (I5).

Most probable minerals present: Muscovite, Quartz, Dolomite, Talc

Visual Comparison: Muscovite, Quartz

Minerals Present: Muscovite, Quartz

SAMPLE I31 BLACK INCLUSION



Comparison: 1 unmatched line 1.2145Å

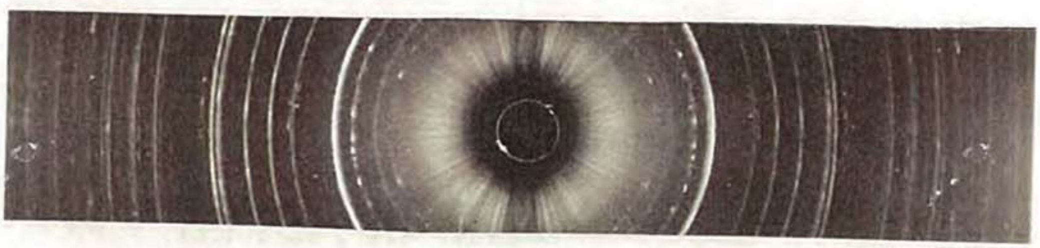
Patterns not included: Magnesite (I37), Talc (I5),Dolomite

Most probable minerals present: Muscovite, Calcite, Talc

Visual Comparison: Muscovite, Calcite

Minerals Present: Muscovite, Calcite

SAMPLE I34 TUNNEL WALL - MARBLE



Comparison

Patterns not included: Tremolite (I19/I20), Magnesite (I6)

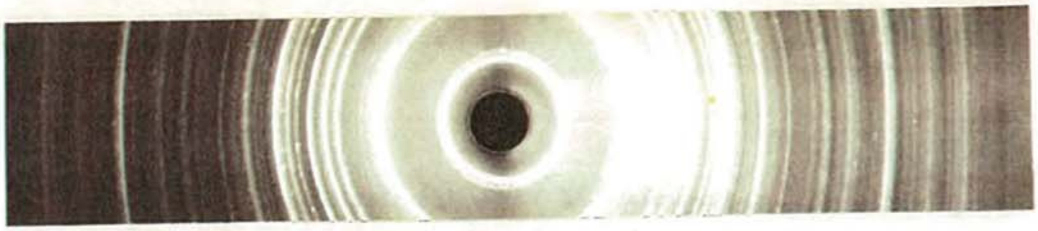
Most probable minerals present: Calcite, Muscovite, Talc

Visual Comparison, Calcite

Minerals Present Calcite

Examples of Patterns Obtained
from the Carbonate Specimens
and their Major Mineral Compo-
sition Obtained from Comparison
with Standards.

SAMPLE I4 FACE 10 AMPHIBOLE



Comparison: 3 unmatched lines 1.2586Å, 1.0823Å, 1.074Å

Patterns not included: Chlorite (I42), Chlorite (I4)
Dolomite

Most probable minerals present: Tremolite, Talc, Magnesite

Visual Comparison: Talc, Tremolite, Magnesite

Minerals Present: Talc, Tremolite, Magnesite

SAMPLE I6 QUARTZ

Comparison

Patterns not included: Calcite (I34), Chlorite (I4)
Tremolite (I19/I20)

Most probable minerals present: Magnesite, Dolomite,
Talc

Visual Comparison: MAGNESITE, Talc

Minerals Present: Magnesite, Talc

SAMPLE I11 CARBONATE - TALC INCLUSION

Comparison: 1 unmatched line 1.2143Å

Patterns not included: Chlorite (I42), Chlorite (I4)

Most probable minerals present: Magnesite, Dolomite, Talc

Visual Comparison: Talc, Magnesite, Calcite

Minerals Present: Talc, Magnesite, Calcite

SAMPLE I14 SEAM 4 INCLUSION IN TALC

Comparison

Patterns not included: Magnesite (I37), Chlorite (I4), Muscovite (I35), Tremolite (I19/I20)

Most probable minerals present: Dolomite, Talc

Visual Comparison: Talc, Dolomite

Minerals Present: Talc, Dolomite

SAMPLE I18 FACE 3 MAGNESITE AND TALC

Comparison:

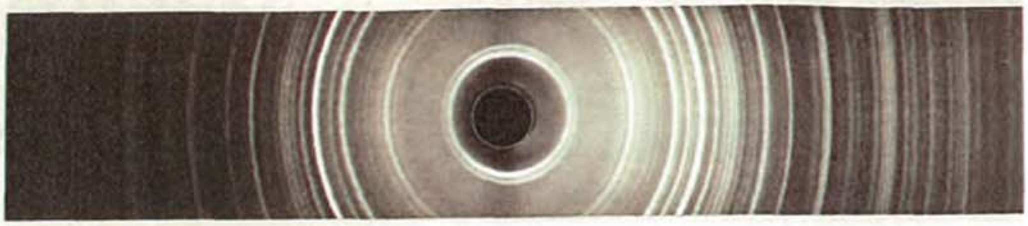
Patterns not included: Talc (I5), Tremolite (I19/I20)

Most probable minerals present: Dolomite, Magnesite, Chlorite

Visual Comparison: Dolomite, Talc Chlorite

Minerals Present: Dolomite, Talc, Chlorite.

SAMPLE I 19 IMPURITY IN TALC AND QUARTZ



Comparison:

Patterns not included: Magnesite (I37)

Most probable minerals present: Tremolite, Dolomite, Muscovite, Talc

Visual Comparison: Talc, Tremolite, Magnesite.

Minerals Present: Talc, Tremolite, Magnesite

SAMPLE I21 FACE 2 OCCLUSION (MAGNESITE)

Comparison:

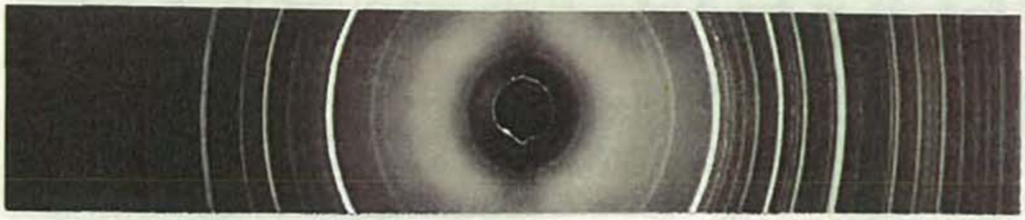
Patterns not included: Calcite (I34), Chlorite (I4), Muscovite (I35), Tremlite (I19/I20)

Most probable minerals present: Dolomite, Magnesite, Talc

Visual Comparison: Talc, Magnesite, Dolomite

Minerals Present: Talc, Magnesite, Dolomite

SAMPLE I22 MAGNESITE, DOLOMITE, TALC



Comparison:

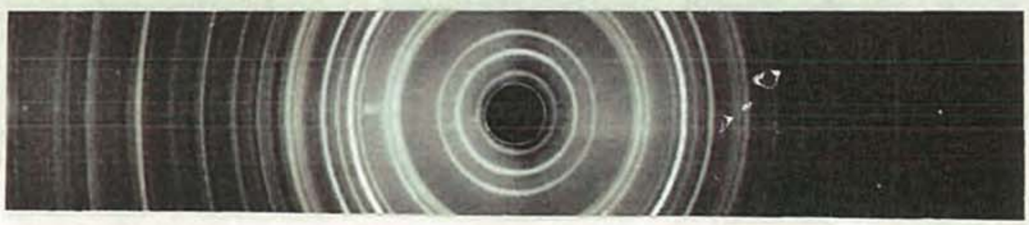
Patterns not included: Calcite (I84), Talc (I45), Talc (I46) Muscovite (I35), Tremolite (I19/I20).

Most probable minerals present: Dolomite, Magnesite, Chlorite, Talc.

Visual Comparison: Talc, Dolomite.

Minerals Present: Talc, Dolomite

SAMPLE I30 TALC AND OTHERS



Comparison:

Patterns not included: Magnesite (I37), Talc (I5), Tremolite (I19/I20).

Most probable minerals present: Dolomite, Chlorite, Muscovite, Talc.

Visual Comparison: Talc, Chlorite

Minerals Present: Talc, Chlorite

SAMPLE I35 MASSIVE CARBONATE. END OF WORKING

Comparison:

Patterns not included: Tremolite (I19/I20)

Most probable minerals present: Muscovite, Magnesite, Chlorite

Visual Comparison: Magnesite, Talc, Chlorite

Minerals Present: Magnesite, Talc, Chlorite

SAMPLE I37 CARBONATE AND TALC

Comparison

Patterns not included: Calcite (I34), Chlorite (I4), Muscovite (I35).

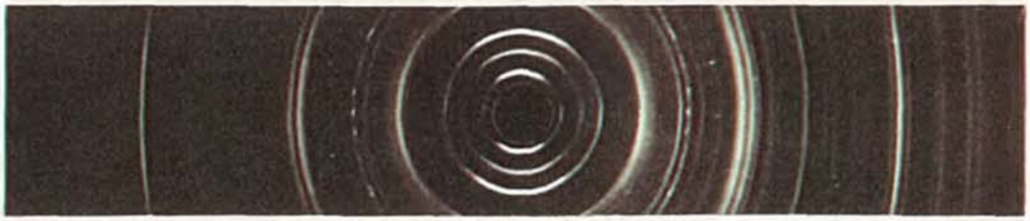
Most probable minerals present: Magnesite, Dolomite, Talc

Visual Comparison: Magnesite, Talc

Minerals Present: Magnesite, Talc

Examples of Patterns and Major Mineral Content of Those Specimens Classified as Talc Types Obtained by Comparison.

SAMPLE I2 SORTING PIECES



Comparison

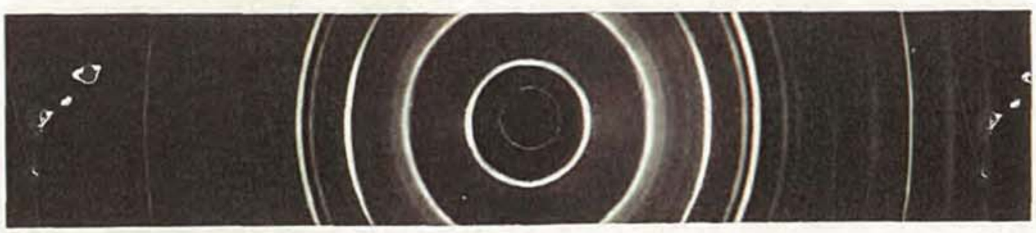
Patterns not included: Tremolite (I19/I20)

Most probable minerals present: Chlorite, Magnesite, Talc

Visual Comparison: Chlorite, Talc

Minerals Present: Chlorite, Talc

SAMPLE I3 COLOURED TALC



Comparison:

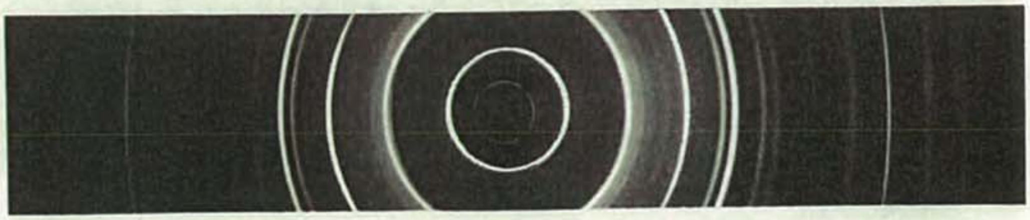
Patterns not included: Chlorite (I42), Chlorite (I4), Muscovite (I35), Magnesite (I6), Tremolite (I19/I20), Dolomite.

Most probable minerals present: Talc

Visual Comparison: Talc

Minerals present: Talc

SAMPLE I5 GENERAL ORE



Comparison: 2 unmatched lines 18.1157Å 7.0073Å

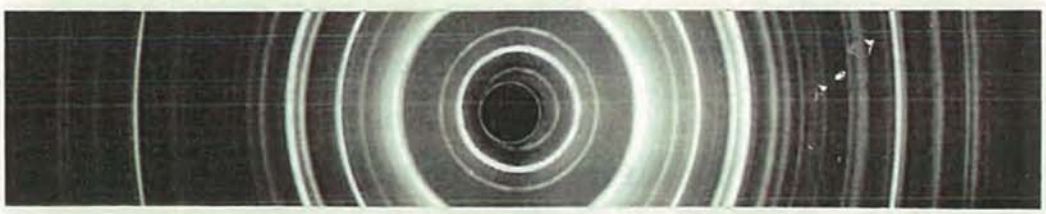
Patterns not included: Chlorite (I42), Chlorite (I4), Muscovite (I35), Dolomite.

Most probable minerals present: Talc, Magnesite

Visual Comparison: Talc

Minerals present: Talc

SAMPLE I8 MASSIVE TALC



Comparison

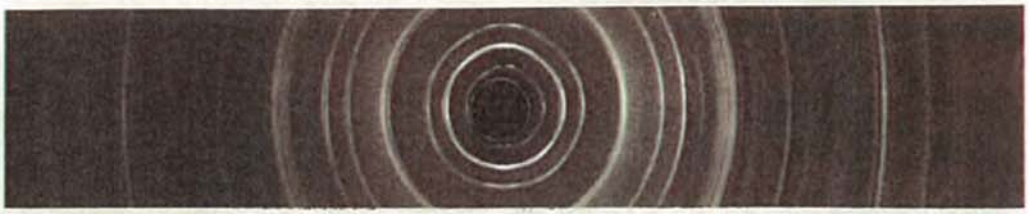
Patterns not included: Magnesite (I6), Tremolite (I19/I20).

Most probable minerals present: Talc, Chlorite

Visual Comparison: Talc, Chlorite

Minerals Present: Talc, Chlorite

SAMPLE I9 FACE 1 GREY TALC



Comparison

Patterns not included: Calcite (I34), Magnesite (I37), Muscovite (I35), Magnesite (I6), Tremolite (I19/I20).

Most probable minerals present: Talc, Chlorite

Visible Comparison: Talc, Chlorite

Minerals Present: Talc, Chlorite

SAMPLE I10 GRANULAR TALC

Comparison

Patterns not included: Calcite (I34), Magnesite (I37), Chlorite (I42) Chlorite (I4), Muscovite (I35), Magnesite (I6) Tremolite (I19/I20)

Most probable minerals present: Talc, Dolomite

Visible Comparison: Talc, Dolomite

Minerals Present: Talc, Dolomite

SAMPLE I24 TALC FACE #

Comparison:

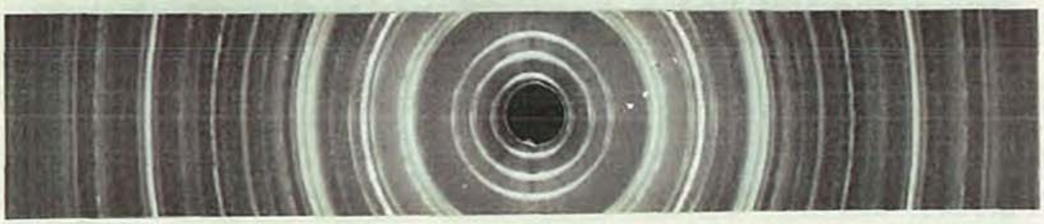
Patterns not included: Muscovite (I35), Tremolite (I19/I20) Magnesite (I6).

Most probable minerals present: Talc, Chlorite, Dolomite, Magnesite

Visual Comparison: Dolomite, Magnesite, Talc

Minerals Present: Dolomite, Magnesite, Talc

SAMPLE I26 TALC INCLUSIONS



Comparison

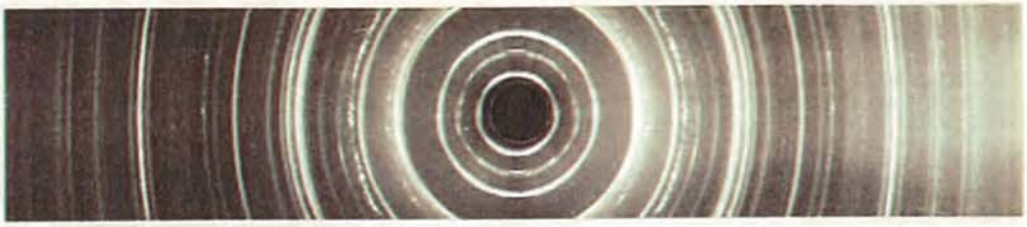
Patterns not included: Calcite (I34), Tremolite (I19/I20)

Most probable minerals present: Talc, Chlorite, Dolomite

Visual Comparison: Talc, Chlorite

Minerals Present: Talc, Chlorite

SAMPLE I28 QUARTZ TALC



Comparison

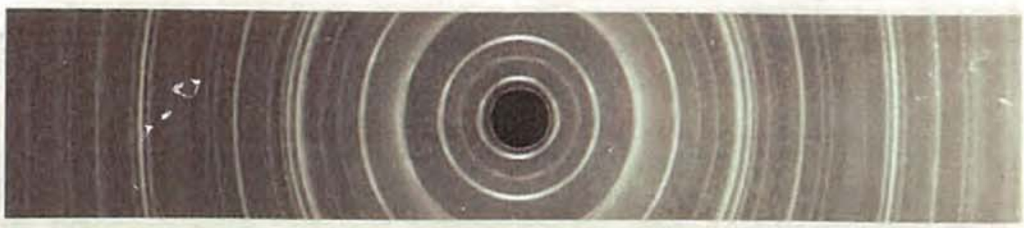
Patterns not included: Muscovite (I35), Tremolite (I19/I20) Magnesite (I6), Dolomite

Most probable minerals present: Chlorite, Talc, Quartz

Visual Comparison: Chlorite, Talc, Quartz

Minerals Present: Chlorite, Talc, Quartz

SAMPLE I32 OCCLUSION FACE 2



Comparison

Patterns not included: Muscovite (I35), Tremolite (I19/I20) Dolomite

Most probable minerals present: Chlorite, Talc, Magnesite

Visual Comparison: Chlorite, Talc

Minerals Present: Chlorite, Talc

SAMPLE I33 TALC END OF WORKING

Comparison:

Patterns not included: Muscovite (I35), Tremolite (I19/I20)

Most probable minerals present: Talc, Chlorite, Magnesite Dolomite

Visual Comparison: Talc, Chlorite, Magnesite

Minerals Present: Talc, Chlorite, Magnesite

SAMPLE I36 GREY TALC

Comparison: 2 unmatched lines 1.2204Å; 1.1517Å

Patterns not included: Calcite (I34), Talc (I46) Tremolite (I19/I20).

Most probable minerals present: Chlorite, Muscovite, Talc

Visual Comparison: Chlorite, Talc

Minerals Present: Chlorite, Talc

SAMPLE I38 TALC AND PYRITE

Comparison: 1 unmatched line 1.041Å

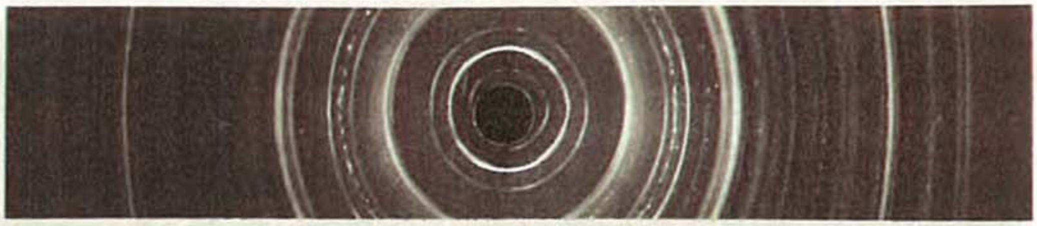
Patterns not included: Chlorite (I42), Chlorite (I4), Muscovite (I35), Tremolite (I19/I20)

Most probable minerals present: Talc, Calcite

Visual Comparison: Talc, Calcite

Minerals Present: Talc, Calcite

SAMPLE I39 S-'Q' FROM CRUSHER



Comparison

Patterns not included: Muscovite, (I35), Tremolite (I19/I20) Magnesite (I6).

Most probable minerals present: Talc Chlorite

Visual Comparison: Talc, Chlorite, Calcite

Minerals Present: Talc, Chlorite, Calcite

SAMPLE I40 PLATEY TALC

Comparison:

Patterns not included: Tremolite (I19/I20)

Most probable minerals present: Talc, Magnesite, Chlorite

Visual Comparison: Talc, Chlorite, Magnesite

Minerals Present: Talc, Chlorite, Magnesite

SAMPLE I41 GOOD SPECIMEN No.2.

Comparison:

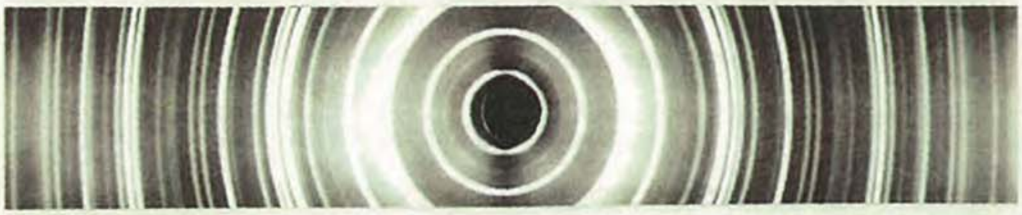
Patterns not included: Calcite (I34), Muscovite (I35), Tremolite (I19/I20), Magnesite (I6), Dolomite

Most probable minerals present: Talc, Chlorite

Visual Comparison: Talc, Chlorite

Minerals Present: Talc, Chlorite

SAMPLE I42 COLOURED TALC No.1.



Comparison

Patterns not included: Magnesite (I37), Talc (I46), Muscovite (I35), Dolomite.

Most probable minerals present: Chlorite, Talc

Visual Comparison: Chlorite, Talc

Minerals Present: Chlorite, Talc

SAMPLE I43 FIBROUS TALC FACE 10

Comparison: 2 unmatched lines 4.8928Å, 4.4431Å

Patterns not included: Calcite (I34), Magnesite (I37), Muscovite (I35), Tremolite (I19/I20)

Most probable minerals Present: Chlorite, Talc

Visual Comparison: Chlorite, Talc

Minerals Present: Chlorite, Talc

SAMPLE I44 PURE TALC FACE 1

Comparison: 1 unmatched line 1.0798

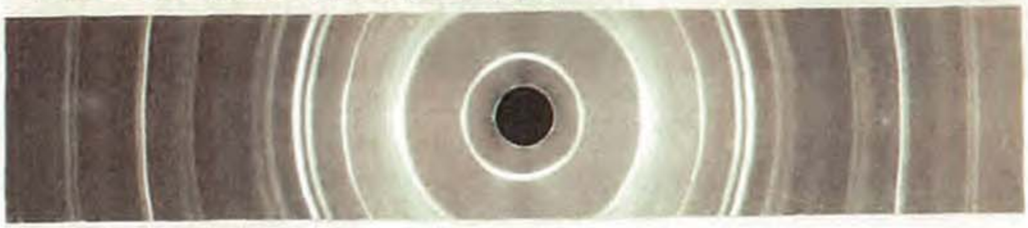
Patterns not included: Magnesite (I37), Talc (I42), Muscovite (I35), Tremlite (I19/I20)

Most probable minerals present: Chlorite, Talc, Dolomite

Visaal Comparison: Talc, Magnesite, Chlorite

Minerals Present: Talc, Magnesite, Chlorite

SAMPLE I45 GOOD SPECIMEN FACE 1



Comparison: 2 unmatched lines 1.0882Å, 1.0505Å

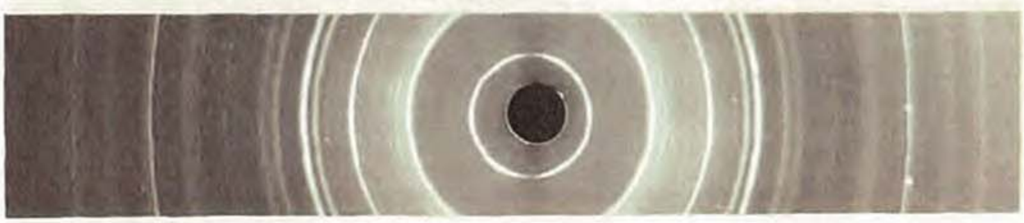
Patterns not included: Calcite (I34), Chlorite (I42), Chlorite (I4) Muscovite (I35), Magnesite (I6), Tremolite (I19/I20), Dolomite.

Most probable minerals present: Talc, Magnesite

Visual Comparison: Talc

Minerals Present: Talc

SAMPLE I46 COLOURED TALC FACE 3



Comparison:

Patterns not included: Chlorite (I42), Chlorite (I4), Muscovite (I35), Tremolite (I19/I20).

Most probable minerals present: Talc, Magnesite

Visual Comparison: Talc, Magnesite

Minerals Present: Talc, Magnesite

Specimen Patterns and Comparison Data for
Samples of Old Powders and ØØØØØ Shipments

SAMPLE BATCH 6 POWDER F1 PW.J. 035

Comparison: 1 unmatched line 8.1972Å

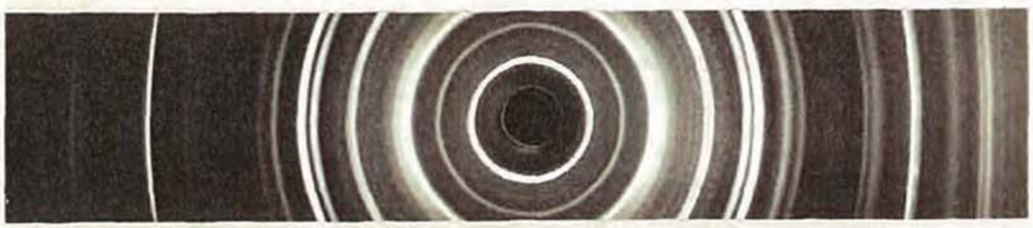
Patterns not included: Muscovite (I35), Tremolite (I19/I20)

Most probable minerals present: Talc, Magnesite, Chlorite

Visual Comparison: Talc, Chlorite, Magnesite

Minerals Present: Talc, Chlorite, Magnesite

SAMPLE BATCH 8 POWDER (S and G) PW.J. 035



Comparison

Patterns not included: Magnesite (I6), Tremolite (I19/I20)

Most probable minerals present: Talc, Magnesite, Boric Acid

Visual Comparison: Talc, Chlorite, Boric Acid

Minerals Present: Talc, Chlorite, Boric Acid

SAMPLE BATCH 9 POWDER T4 P.W.J. 035

Comparison: 1 unmatched line 1. 2587Å

Patterns not included: Tremolite (I19/I20)

Most probable minerals present: Talc, Chlorite, muscovite, Magnesite, Boric Acid

Visual Comparison: Talc, Chlorite, Boric Acid

Minerals Present: Talc, Chlorite, Boric Acid

SAMPLE BATCH 10 POWDER SK18P PW.J. 035

Comparison

Patterns not included: Calcite (I34), Muscovite (I35), Tremolite (I19/I20), Dolomite

Most probable minerals present: Talc, Chlorite, Magnesite, Boric Acid.

Visual Comparison: Talc, Chlorite, Boric Acid

Minerals Present: Talc, Chlorite, Boric Acid

SAMPLE BATCH 11 POWDER LD18P PW.J. 035

Comparison: 1 unmatched line 8.1363Å

Patterns not included: Magnesite (I6), Tremolite (I19/I20) Dolomite

Most probable minerals present: Talc, Chlorite, Boric Acid

Visual Comparison: Talc, Chlorite, Boric Acid, Magnesite

Minerals Present: Talc, Chlorite, Boric Acid, Magnesite

SAMPLE BATCH 12 TALC 1960 PW.J. 025

Comparison: 1 unmatched line 8.12 Å

Patterns not included: Tremolite (I19/I20)

Most probable minerals present. Talc, muscovite, chlorite, Boric Acid.

Visual Comparison: Talc, Chlorite, Boric Acid, Magnesite

Minerals Present: Talc, Chlorite, Boric Acid, Magnesite

SAMPLE BATCH 13 TALC 1961 PW.J. 026

Comparison

Patterns not included: Calcite (I34), Muscovite (I35)
Tremolite (I19/I20)

Most probable minerals present: Talc, Chlorite, Magnesite
Boric Acid

Visual Comparison: Talc, Chlorite, Magnesite, Boric Acid

Minerals Present: Talc, Chlorite, Magnesite, Boric Acid

SAMPLE BATCH 19 S.S. CATHERINA W. 02/05/72

Comparison

Patterns not included: Tremolite (I19/I20)

Most probable minerals present: Talc, Chlorite, Magnesite

Visual Comparison: Talc, Chlorite, Magnesite

Minerals Present: Talc, Chlorite, Magnesite

SAMPLE BATCH 2 TALC S.S. EDNA 'B' 14/02/72

Comparison

Patterns not included: Talc (I45), Tremolite (I19/I20)

Most probable minerals present: Talc, Chlorite

Visual Comparison: Talc, Chlorite

Minerals Present: Talc, Chlorite

CONCLUSIONS

The optical examination has shown that there are a large number of minerals associated with the rock types found both in the talc seam and in the associated rocks. The footwall rocks in contact with the talc are mainly composed of the minerals quartz, muscovite, chlorite, garnet, and some carbonate material both calcite and magnesite. Minor minerals in the footwall contact rocks include epidote, microcline, tremolite and actinolite, sphene, rutile, hornblende, rare talc, biotite, pyrite, pyrrhotite and chalcopyrite. Rock type inclusions into the talc have similar compositions to the footwall rocks but with higher muscovite and chlorite contents. The muscovite was generally an iron rich variety (phengite), while two forms of chlorite were observed namely sheridanite and penninite. Other talc inclusions consist mainly of carbonate minerals, calcite and magnesite in varying quantities. It is with these nodules that some tremolite is found. The rocks further away from the talc seams, namely the gneiss, become richer in quartz and microcline and below these marble occurs.

The carbonate specimens examined by optical means showed that the carbonate minerals, calcite and magnesite, were accompanied by talc, chlorite, tremolite, muscovite, rutile and pyrite, all in minor amounts. In general the carbonate inclusions were large and very discrete in the talc seam itself.

The specimens examined, which can be classified as talc samples, were found to be in the main composed of talc with chlorite as the major contaminant. Some specimens, however, were predominantly composed of chlorite with minor talc inclusions. Other minerals found in association with the talc specimens included garnet, rutile and magnesite with rare tremolite and a quartz or serpentine inclusion. Some differences were observed in the talc itself, some of the talc appearing to be a little murky in texture. X-ray pictures of the clear and murky material showed no differences however.

The powder X-ray examination confirmed the major minerals occurring in the hand specimens and a classification was possible into the three groups already mentioned, i.e. rock types, carbonate samples and talc specimens. The only asbestos type mineral to be detected in the hand samples was tremolite, which was found in three of the specimens. The tremolite was associated with carbonate minerals, namely magnesite and calcite, no tremolite was detected in the talc type specimens. Chlorite was, however, very common in the talc types, some of the specimens being very nearly pure chlorite in composition. There appeared to be some association of the chlorite with coloured talc specimens, especially those with a greyish colour. Other colour variations due to rutile were not detected by X-ray examination.

The examination of consecutive samples at face 1 in the mine showed that the chlorite content can vary very drastically over a 6ft thick section of the talc seam. Patterns obtained from several shipments of ØØØØØ talc showed that chlorite, together with carbonate material, were the major contaminant minerals. This was also true of powder samples ranging back to 1949 in which the only observable difference was the presence of boric acid.

The electron microscope examination of the powdered samples showed that a difference could be drawn between particles produced from the various samples. The carbonates and rock types on the whole produced compact fibre free particles. The talc specimens were, however, plate-like in appearance with varying quantities of lath like particles coupled with fibres which were textile in appearance. Both lath and textile types of particles were not composed of minerals associated with the commercial asbestos industry. Particles formed from the amphibole mineral found at the mine were hardly fibrous in character, the majority of the tremolite breaking to give compact particles. Those fibres formed were short and had a very large diameter when compared with the commercial varieties of asbestos. No amphibole or chrysotile mineral was detected in any of the numerous powders examined.

The Italian talc ØØØØØ contains observable quantities of chlorite and carbonate minerals and could contain any one of the following minerals in very minor amounts: muscovite, quartz, tremolite, garnet and rutile. If small pieces of footwall rock were to contaminate the ore during production, several of the other listed minerals found in the rock type specimens could appear in the shipped product. It is unlikely that they would be present in detectable amounts.

F.D. POOLEY

Project Supervisor